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ABSTRACT

A means for estimating the resource requirements and attendant costs of any configuration of the undergraduate pilot training system (UPT) is described by inputs that are supplied by the user of the model. The inputs consist of data such as UPT graduate requirements, course syllabus requirements, instructor-student ratios, administrative and support manpower relationships, number of aircraft and simulators available, aircraft and simulator utilization rates, amount of facilities available, and cost relationships. The UPT model, which is designed to aid the user in examining long-range alternatives in yearly increments for up to 20 years, calculates the costs associated with these resource requirements in terms of research and development costs, investment costs, and operating costs. Among the alternatives that can be examined are changes in the numbers and types of training aircraft and simulators used; adjustments in prescribed syllabus hours for flight, simulator or classroom training; changes in numbers of graduates required; modifications of aircraft or simulator utilization rates; and changes in airspace, facilities (e.g., runways) or numbers of training bases. For related documents, see AC 010 340-346. (Author/DB)

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MEMORANDUM
RM-6083-PR
DECEMBER 1969

THE PILOT TRAINING STUDY:
A Cost-Estimating Model for Undergraduate Pilot Training

S. L. Allison

PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

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A Cost-Estimating Model for Undergraduate Pilot Training

S. L. Allison

This research is supported by the United States Air Force under Project RAND—Contract No. F44620-67-C-0045—monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of the United States Air Force.

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PREFACE

In April 1967, the Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs) formed a Pilot Advisory Committee to study "Pilots as a National Resource." The Committee consisted of the Assistant Secretary and a representative of Staff members from Rand were invited to attend the early meetings of the Committee. The outgrowth was that the Air Force member requested RAND to accept responsibility for examining the Air Force pilot training process. The objective of the Rand Pilot Training Study was to develop a series of computer models for use in estimating the resources required to produce pilots and the costs of training them. Further, the models were to be designed for sensitivity analyses and long-range planning.

For the convenience of readers whose interests may not extend to all aspects of the pilot training process, the results of the study are presented in eight volumes, as follows:

Volume		
I	RM-6080-PR	The Pilot Training Study: Personnel Flow and the PILOT Model, by W. E. Mooz.
II	RM-6081-PR	The Pilot Training Study: A User's Guide to the PILOT Computer Model, by Lois Littleton.
III	RM-6082-PR	The Pilot Training Study: Precommissioning Training, by J. W. Cook.
IV	RM-6083-PR	The Pilot Training Study: A Cost-Estimating Model for Undergraduate Pilot Training, by S. L. Allison.
V	RM-6084-PR	The Pilot Training Study: A User's Guide to the Undergraduate Pilot Training Computer Cost Model, by Lois Littleton.
VI	RM-6085-PR	The Pilot Training Study: Advanced Pilot Training, by P. J. Kennedy.
VII	RM-6086-PR	The Pilot Training Study: A Cost-Estimating Model for Advanced Pilot Training (APT), by L. E. Knollmeyer.
VIII	RM-6087-PR	The Pilot Training Study: A User's Guide to the Advanced Pilot Training Computer Cost Model (APT), by H. E. Boren, Jr.

This Memorandum, Volume IV of the series, describes USAF undergraduate pilot training (UPT) and a computer model developed for use in estimating both the resources required and the attendant costs for any given configuration of the UPT training system.

A description of the USAF Survival School and a model for use in estimating resources and associated costs of survival training are included as an appendix to this Memorandum.

Although an understanding of undergraduate pilot training and survival training may be obtained from this Memorandum without reference to the other Memorandums in the series, the reader will find it useful to read Volume I for an understanding of the part that these training activities play in the total process of training USAF pilots.

SUMMARY

The model described in this document provides a means for estimating the resource requirements and attendant costs of any configuration of the undergraduate pilot training (UPT) system.

The UPT system is described by inputs that are supplied by the user of the model. The inputs consist of data such as UPT graduate requirements, course syllabus requirements, instructor-student ratios, administrative and support manpower relationships, number of aircraft and simulators available, aircraft and simulator utilization rates, amount of facilities available, and cost relationships. Given these inputs, the model computes the manpower, equipment, and facilities required for the UPT training. The model then calculates the costs associated with these resource requirements in terms of research and development costs, investment costs and annual operating costs.

The UPT model is designed to aid the user in examining long-range alternatives. For this reason, the model operates in yearly increments for up to 20 years.

Among the alternatives that can be examined are changes in the numbers and types of training aircraft and simulators used; adjustments in prescribed syllabus hours for flight, simulator or classroom training; changes in numbers of graduates required; modifications of aircraft or simulator utilization rates; and changes in airspace, facilities (e.g., runways) or numbers of training bases.

The UPT model may be used in two ways: It may be used in conjunction with the other pilot training models (see Preface) to estimate the overall impact of pilot training alternatives. It also may be used separately to examine UPT alternatives while ignoring their effects on other training activities.

The UPT resource and cost model is programmed in Fortran IV and is currently being operated on the IBM 360 computer at Rand.

ACKNOWLEDGMENTS

Acknowledgments are due to many individuals in the Air Force and at Rand for the invaluable help that they provided throughout the preparation of this Memorandum. Because of the great number of people to whom credit is due, it is not practicable to make individual acknowledgments. The author is, therefore, obliged to use this means of expressing his appreciation.

The author is especially indebted to personnel of Headquarters, Air Training Command (ATC), notably to those in the following staff offices:

Directorate	Deputy Chief of Staff
Programs	Civil Engineering
Resource Planning	Civil Engineering
Management Analysis	Comptroller
Logistics	Materiel
Maintenance-Engineering	Materiel
Operational Planning	Operations
Pilot Training	Operations
Assignments	Personnel
Personnel Plans	Personnel
Manpower and Organization	Plans
Plans and Programs	Plans
Training Development	Plans

The study could not have been accomplished without the information, advice, and review assistance that was so unstintingly provided by the personnel of these directorates.

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I. INTRODUCTION

Air Force pilot candidates receive their basic flight qualification training* in the 53-week Undergraduate Pilot Training (UPT) course conducted by the Air Training Command (ATC). Upon graduation from UPT, the new pilot is sent to the USAF Survival School (SS) for a short course of instruction in survival techniques. He is then assigned to one of the many Advanced Pilot Training (APT) schools for training to qualify as a pilot of a specific type and model of USAF operational aircraft. These three training programs (UPT, SS, and APT) and the computer models that have been developed for use in estimating their respective resource requirements and attendant costs are described in Volumes IV-VIII of the Pilot Training Study.**

Only commissioned officers are accepted for pilot training. For that reason, the study examines the three training sources from which the Air Force obtains its new officers: the Air Force Academy (AFA), Reserve Officer Training Corps (ROTC), and Officer Training School (OTS). Volume III* of the Pilot Training Study describes these precommissioning training processes and documents a methodology for estimating the resources required and related costs.

Because of the importance and complexity of the management of pilot flows within the Air Force, Volumes I and II* of the study are devoted to a description of a simulation model, called the PILOT model, which was developed to synthesize the pilot flows. The PILOT model is used to examine policies regarding pilot flows and their effect on pilot training rates and costs.

These models are tools for long-range planning--that is, for planning 5 to 20 years or more into the future. They are not designed to help solve day-to-day management problems. Although, theoretically, a computer model could be developed to be used for both short-range management problems and long-range planning problems, such an all-purpose model would be inefficient. For example, consider the relatively short-run management problem of obtaining a sufficient number of trained UPT permanent-party personnel (personnel other than students) permanently assigned to the UPT base) within each Air Force Specialty Code (AFSC) category. To solve the problem, quarterly estimates must be made of the personnel requirements within each AFSC category. However, for long-range planning purposes, an estimate of only the annual officer, airman, and civilian requirement is sufficient. If a long-range UPT planning model were developed that would also aid in solving short-run management problems, such as the personnel planning problem, the cost estimates would not be improved significantly, and the task of supplying the very large number of inputs would be greatly disproportionate to the benefits gained.

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*Some preliminary flight indoctrination training is given to pilot candidates at the Air Force Academy and at some ROTC schools.

**See Preface.

The UPT course provides flight training in three aircraft: the single-engine, propeller-driven T-41; the subsonic jet T-37; and the supersonic T-38. The training is conducted at 10 ATC bases and produces almost 4000 pilots annually. During FY 1969, more than one million training hours were logged in the T-37 and T-38 aircraft, and over 3000 training sorties were launched each day from the UPT bases.

The UPT model provides a means for estimating the resources that will be required and the costs that will be incurred in conducting undergraduate pilot training. It is a tool for measuring the long-range effects of alternative policies and conditions such as changes in the required number of graduates, changes in course syllabus and changes in the training facilities. For example, the model can answer the following kinds of questions: What will be the impact on resources and costs of a substantial increase (or reduction) in UPT graduates? What will be the effect on costs of changing the syllabus flying hour requirement? How will the UPT training capacity be affected by the opening of a new UPT base? Will more aircraft be needed if the present aircraft utilization rates are reduced? Will more simulator space be required if larger flight simulators are used? What will be the impact of introducing a new type of training aircraft into the UPT course?

The present UPT system is described in Section II. In Section III a general description of the UPT model is presented, and in Section IV the uses of the model are described. Section V is a detailed description of the model.

The appendix discusses USAF survival training, and a model of this training.

II. DESCRIPTION OF UNDERGRADUATE PILOT TRAINING

Although the UPT model may be used in estimating resources and attendant costs of virtually any future configuration of UPT, its design was influenced by the manner in which UPT is currently conducted. The present UPT system is described in this section.

The USAF undergraduate pilot training course is the source from which the Air Force fills its continuing needs for new pilots. One concept underlying UPT is that its graduates must be capable of transition, with advanced training, into any aircraft in the Air Force inventory. For this reason, all undergraduate pilot training is taught in a single, standard 53-week course.

PILOT TRAINING FLOW

The UPT course is one of several training activities through which an Air Force pilot passes in the course of his career. He must be a commissioned officer in order to be admitted to undergraduate pilot training. UPT students receive their wings as rated USAF pilots upon graduation, but they must receive additional training to qualify as a pilot of a specific type and model of operational aircraft.

The typical training path is illustrated in Fig. 1.

RELATIONSHIP OF UPT TO OTHER PILOT TRAINING

Each of the steps in the training sequence depicted in Fig. 1 is described in detail in other volumes of the Pilot Training Study.* The following brief descriptions are therefore offered only to point up the interdependence that exists among the several training activities that are needed to produce an operationally-qualified pilot.

Precommissioning Training

Civilians who wish to become Air Force pilots must first become commissioned officers by graduating from the Air Force Academy, Officer

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*See Preface.

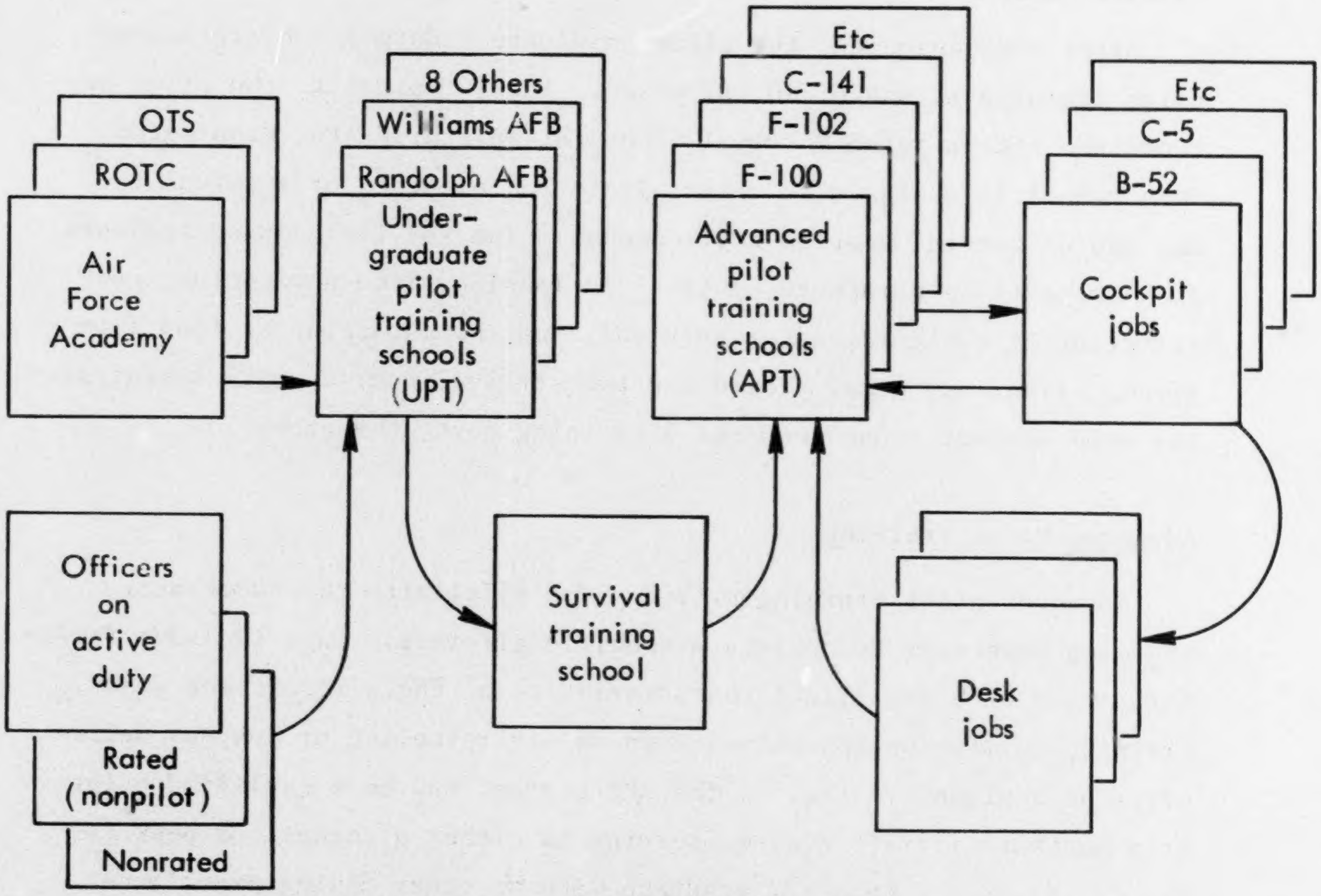
OTS
ROTC
Air Force Academy
8 Others
Williams AFB
Randolph AFB
Undergraduate pilot training schools (UPT)
Etc
C-141
F-102
F-100
Advanced pilot training schools (APT)
Etc
C-5
B-52
Cockpit jobs
Officers on active duty
Rated (nonpilot)
Nonrated
Survival training school
Desk jobs

Fig. 1— Pilot training flow

Training School, or Reserve Officer Training Corps. The Air Force Academy at Colorado Springs is the Air Force counterpart of the Army's West Point, and the Navy's Annapolis. The Academy trains selected young men in a four-year college curriculum combined with military training. The Reserve Officers Training Corps (ROTC) program is conducted at about 170 college campuses. Credit toward the Bachelor degree is usually given for courses taken in military training.[*] Students are commissioned upon graduation from college. Officer Training School (OTS) provides military training to qualified college graduates in a 12-week course. OTS is conducted at Lackland AFB in Texas.

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[*] A few schools, e.g., Harvard, may not do so.

Survival Training

After commissioning, the pilot candidate undergoes undergraduate pilot training at one of 10 UPT bases. Then, typically, the pilot attends the ATC-operated Survival School at Fairchild AFB, Washington. This school is designed to teach pilots the elements of survival in any one of several hostile environments. The survival course includes such subjects as parachute control and landing, land navigation, construction of shelters, water survival, and the obtaining of food from plants, fish, and game. There are two survival courses with essentially the same content: One requires 9 training days, the other 15.

Advanced Pilot Training

Advanced pilot training provides the pilot with the additional training necessary to operate a specific aircraft. This includes familiarization with the flight characteristics of the aircraft and also training in mission objectives such as air refueling or weapons delivery. As depicted in Fig. 1, the APT student may be a qualified pilot from another aircraft system, serving in either a cockpit or desk capacity, or he may be a UPT graduate with no other flying experience.

The advanced pilot training is conducted by units variously referred to as Combat Crew Training Schools (CCTS), Replacement Training Units (RTU), Transport Training Units (TTU), or by the general designation of Advanced Pilot Training, depending on the organization that conducts the training. Each school is under the jurisdiction of the major command of primary responsibility, that is, the command that is the major user of the particular aircraft. The command establishes the syllabus and operates the school. Schools exist for almost all of the widely used active aircraft in the inventory, with several types of aircraft having schools on more than one base, and some bases having more than one school. The lengths of the courses range from 2 to 30 weeks.

CCTS and TTU training is conducted by training squadrons, whereas operational squadrons conduct the RTU instruction as an added duty while maintaining their operational readiness posture. This is the only salient difference.

After a student graduates from the appropriate APT course, he is assigned to an operational unit. His training is continued all through his tour of duty as a pilot in order to maintain proficiency in combat skills and to give him the experience necessary for upgrading from one pilot position to another.

TRAINING CAPACITY

Undergraduate pilot training capacity was increased in June 1969 by the transfer of Columbus AFB, Mississippi, from the Strategic Air Command to ATC for use as a UPT base. This provides, roughly, a 10 percent increase in training capacity. There are now 10 UPT bases: five in Texas and one each in Alabama, Arizona, Georgia, Oklahoma, and Mississippi.*

Columbus AFB, Mississippi
Craig AFB, Alabama
Laredo AFB, Texas
Laughlin AFB, Texas
Moody AFB, Georgia
Randolph AFB, Texas
Reese AFB, Texas
Vance AFB, Oklahoma
Webb AFB, Texas
Williams AFB, Arizona

Each of these bases, except Randolph and Williams, is used exclusively for the UPT program.

It should be noted that training capacity is dependent upon a number of factors in addition to the availability of instructors, training aircraft and simulators, and student dormitory and other facilities. Runways are, of course, essential; at present, each of the ten bases has either two or three runways. A related consideration is the amount of airspace allocated to the base by the Federal Aviation Agency (FAA). Consideration must also be given to the weather conditions peculiar to each base. Bases differ both as to the annual average number of days of flyable weather and in seasonal variations in the times when weather conditions are most likely to interfere with flight training schedules.

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* UPT instruction given to USAF officers at Sheppard AFB, Texas, is not included in this description because (1) the number of U.S. officers in training there is relatively small, and (2) the curriculum, being shaped to meet the needs of trainees from the German Air Force, differs from the standard curriculum employed at the other ten UPT bases.

QUALIFICATION REQUIREMENTS FOR ADMISSION

To qualify for admission to UPT, the applicant must:

- Be a male commissioned officer of the United States or of a MAP-recipient country,
- Pass the prescribed physical examination,
- Be not less than 20½ or more than 26½ years old at the time of application, and not more than 27½ when entering training,
- Have scored well on the Air Force Officer Qualification Test (AFOQT) and the pilot selection tests.

SOURCES OF STUDENTS

UPT students come from several sources. The percentage of fiscal year 1969 entries from each source is shown in Table 1.

Table 1

PERCENTAGE OF UPT ENTERING STUDENTS BY SOURCE, FY 1969

	(%)
Active Air Force Sources	
Officer Training School	46
Reserve Officer Training Corps	27
Air Force Academy	9
Non-rated officers on active duty	6
Rated officers on active duty	1
Subtotal	89
Other Sources	
Air National Guard	4
Marine Corps	4
Foreign	3
Total, all sources	100

The Officer Training School supplies nearly half of the UPT students, and Reserve Officer Training Corps more than one quarter. The Academy percentage includes some graduates from the U.S. Military Academy and the U.S. Naval Academy who desire to become Air Force pilots. The "rated" category consists of officers on active duty who hold flying ratings other than pilot (e.g., navigator); "non-rated" are officers who are accepted for UPT from duty assignments such as civil engineer. Pilot candidates from "other sources" do not add to the pilot strength of the Air Force. Foreign students are trained under agreements with their respective countries. Germany, Norway, Denmark, Jordan, Iran, Colombia, and South Vietnam are among the nations represented.

REASONS FOR STUDENT ATTRITION

Although most UPT students are highly motivated, about one-fourth fail to complete the UPT course. The reasons for their attrition (elimination) are shown below for FY 1969:

	(%)
Training deficiency	65
Self-initiated elimination	12
Medical	13
Fear of flying	9
Other, including fatality	1

Nearly all "training deficiency" eliminations are attributable to flying deficiencies, but a few of them are due to academic failure. About one in every eight of those who fail to complete training is released from UPT at his own request. Approximately the same percentage of the eliminations is for medical reasons. Chronic airsickness is one cause. Another is that some trainees are found to have inadequate vision to pilot an aircraft even though all trainees passed physical examinations before being admitted to UPT. The "fear of flying" category consists mainly of trainees who are afraid of the responsibility of being in charge of the aircraft; very few have fear of flying as passengers.

ATTRITION DATA BY STUDENT SOURCES

Table 2 shows the attrition record of each trainee source for FY 1969.* Historically, the OTS graduates and officers on active duty in non-rated (non-flying) specialties experience the highest attrition rates. Rated officers (most of whom are navigators) experience the lowest attrition. This is to be expected because rated officers have

---

*Attrition percentages shown in Table 2 reflect UPT overall attrition experience for one year. The model, however, uses attrition rates for each training phase. (See Table 5.)

Table 2

ATTRITION RECORD BY SOURCE, FY 1969

	Percentage of Entrants who Attrited
Active Air Force Sources	
Officer Training School	34
Non-rated officers on active duty	34
Reserve Officer Training Corps	22
Air Force Academy	12
Rated officers on active duty	7
Other Sources	
Foreign officers	23
Air National Guard	22
Marine Corps	12
Average, all sources	27

INITIAL ASSIGNMENTS OF GRADUATES

Some months before each class graduates, a list is compiled of aircraft systems for which UPT graduates are required. Students list the systems in the order of their preference for first-tour assignment. Then, upon graduation they are assigned to an aircraft system according to their class standing: Those highest in the class ranking receive the first choice of the available slots. Table 3 shows the number and percentage of FY 1969 graduates who were assigned to each aircraft type.

NUMBER OF GRADUATES, FY 1947 THROUGH FY 1969

The UPT pilot production schedules are geared to changing Air Force needs for pilots and, consequently, the UPT output has varied widely over the years. Figure 2 shows the number of UPT graduates in fiscal year 1947 through 1969.

During the early 1950s, the UPT production was increased to meet the demands of the Korean conflict. Afterward, the Air Force found itself with an excess of rated personnel and began to cut production. Then, as the need increased for pilots in Vietnam, UPT production was

Table 3

INITIAL ASSIGNMENTS OF UPT GRADUATES
TO AIRCRAFT SYSTEMS, FY 1969

Type of Assignment	Number	Percent
Jet		
Pilot Instructor Training ...	444[a]	13.8[a]
Fighter	517	16.1
Bomber	65	2.0
Cargo/Tanker	505	15.7
Other	3	.1
Subtotal Jet	1534	47.7
Turboprop		
Cargo	519	16.1
Other	47	1.5
Subtotal Turboprop	566	17.6
Conventional		
Cargo	749	23.2
Other	367	11.4
Subtotal Conventional	1116	34.7
Total	3216	100.0

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[a] These graduates attended either the T-37 or T-38 pilot instructor course, and then returned to a UPT base as instructor pilots. At the end of FY 1969, about 45 percent of the UPT pilot instructor force were new UPT graduates (first-tour pilots) and 55 percent experienced pilots.

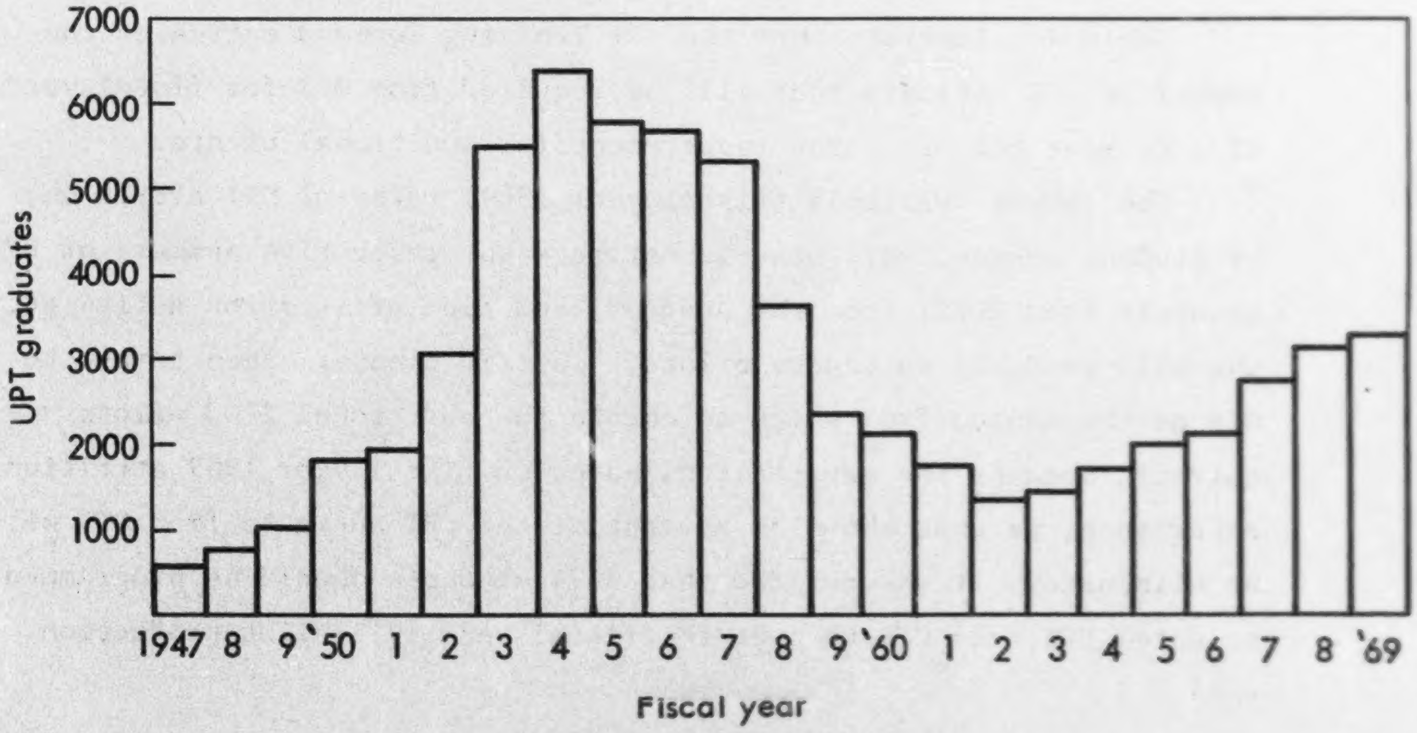

Fig. 2—Number of UPT graduates by fiscal year

again stepped up. It is programmed to reach about 3800 in fiscal year 1971 and to remain at that level through fiscal year 1974.

SPECIAL ROLE OF OTS IN FILLING PILOT-PRODUCTION QUOTAS

One important aspect of the management of pilot flows is the balancing of UPT entrants, by source, to produce the desired number of Air Force pilots. The calculations below exclude "other sources" students.

The desired entry mix is usually set in January for pilot trainees who are to be entered the following fiscal year (and who, upon successful completion of training, will be graduated one fiscal year later). By January, the number of Academy and ROTC students who are about to graduate and who have elected pilot training is available. The deadline for considering the flight training applications of active duty officers has also passed. The portion of the UPT quota that is not filled from these sources is then allotted to OTS.

Because OTS training requires only 12 weeks, OTS officer production can be sharply increased or cut back in a relatively short time. For this reason, Air Force planners use OTS as the balancing (supplemental) source from which to obtain UPT entrants in whatever numbers are needed to fill the projected pilot-production requirements.

Table 4 illustrates how the Air Training Command estimated the number of UPT entrants that will be required from OTS for fiscal year 1971 to meet the Air Force requirement for additional pilots.

The latest available (fiscal year 1969) rates of UPT attrition, by student source, were used to estimate the respective numbers of UPT students from ROTC, from the Academy, and from officers on active duty, who will graduate to become pilots. The ATC planners then turned to OTS as the source from which to obtain the additional 2103 pilots required. Because the expectation, based on fiscal year 1969 attrition experience, is that about 34 percent of the UPT entrants from OTS will be eliminated, it was decided that 3174 students should be programmed to enter UPT from OTS to meet the fiscal year 1971 pilot-production goal.

Table 4

CALCULATION OF NUMBER OF UPT ENTRANTS NEEDED FROM OTS FOR FY 1971

Source	UPT Entries	Estimated Percent Attrition[a]	Estimated Number UPT Graduates[b]
TORC	1472	22	1144
Air Force Academy	436	12	386
Non-rated on active duty	194	34	127
Rated on active duty	67	7	62
Total, less OTS			1719
Total number UPT graduates required			3822
Available from above sources			1719
Balance from OTS	3174[b]	34	2103

[a] Rates of attrition are rounded.

[b] Actual (unrounded) attrition percentages were used in calculating the estimated numbers of UPT graduates and the number of OTS entries.

CURRICULUM

The UPT course is taught in three training phases of increasing difficulty. Students receive a combination of flying, academic, and officer training in each phase. Instrument trainer (simulator)* instruction is given only in the last two phases. The entire course is taught at each of the 10 UPT bases; students therefore receive all three phases at a single base.

Table 5 lists the subjects that comprise the UPT curriculum and shows the approximate number of hours scheduled to be devoted to each subject in each of the three training phases. It also shows the approximate length of each phase, in weeks.

Phase I Flight Training

The present Phase I was introduced into the UPT course several years ago. This initial training phase serves to eliminate students

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*For convenience, the term "simulator" is used throughout this Memorandum to refer to both instrument trainers and flight simulators. The term "flight simulator" commonly refers to a more sophisticated device than the instrument trainers used in UPT. Flight simulators duplicate flight with true aerodynamic relationships, and often duplicate motion, vision or sound.

Table 5

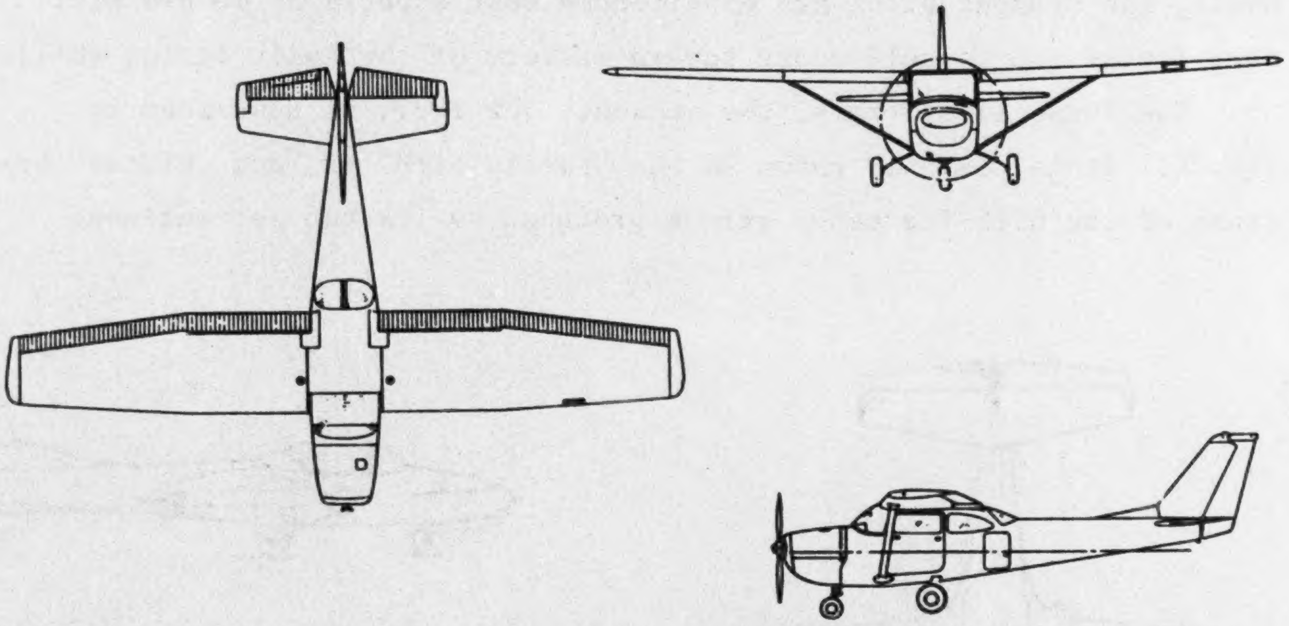
SUMMARY OF UPT COURSE

Training Course	Syllabus Hours			
	All Phases	Phase I	Phase II	Phase III
Flying Training[a]				
Contact flying	122	30	55	37
Instrument	51	---	21	30
Navigation	25	---	9	16
Formation	41	---	5	36
As needed	1	---	---	1
Total	240	30	90	120
Simulator Training				
T-4	23	---	23	---
T-7/T-26	32	---	---	32
Total	55	---	23	37
Academic Training[b]				
Airmanship	14	14	---	---
Aviation physiology	34	29	5	---
Physiological support	10	10	---	---
Systems operations	34	6	12	16
Principles of flight	10	---	10	---
Aural code	10	---	2	8
Flight instruments	13	---	13	---
Navigation	25	---	25	---
Instrument procedures/ radio aids	38	---	26	12
Flight planning	46	---	25	21
Weather	30	---	30	
Flying safety	6	1	2	3
Applied aerodynamics	19	---	---	19
Total	289	60	150	79
Officer Training[b]				
Orientation/Processing	28	28	---	---
Officer career planning	6	---	---	6
Marksmanship	6	---	---	6
Counterinsurgency	7	---	---	7
Physical training	125	15	40	70
Total	172	43	40	89
Training weeks (approx)	53	7.5	19.5	26

[a] Rounded.

[b] Academic and officer training hours have been allocated to the phase in which they are normally taught, as indicated by the Syllabus of Instruction for Undergraduate Pilot Training (T-41/T-37/T-38), Nr. P-V4A-A, Air Training Command, March 1969.

who lack the necessary aptitude for flying before a heavy investment is made in their training. Phase I training requires 7 to 8 weeks, depend depending upon weather, and utilizes the inexpensive, single-engine, propeller-driven T-41 aircraft described in Fig. 3. Students from ROTC and the Air Force Academy who have completed light plane training fly only 18 hours in the T-41; all others fly 30 hours.



Size	
Length	26.5 ft
Wing span	36.2 ft
Height	8.6 ft
Takeoff weight	2300 lb
Features	
Crew	2
Seating	side-by-side

Performance	
Cruising speed	110 kn
Maximum speed	121 kn
Stalling speed	40 kn
Service ceiling	13,100 ft
Range	526 n mi
Manufacturer	Cessna

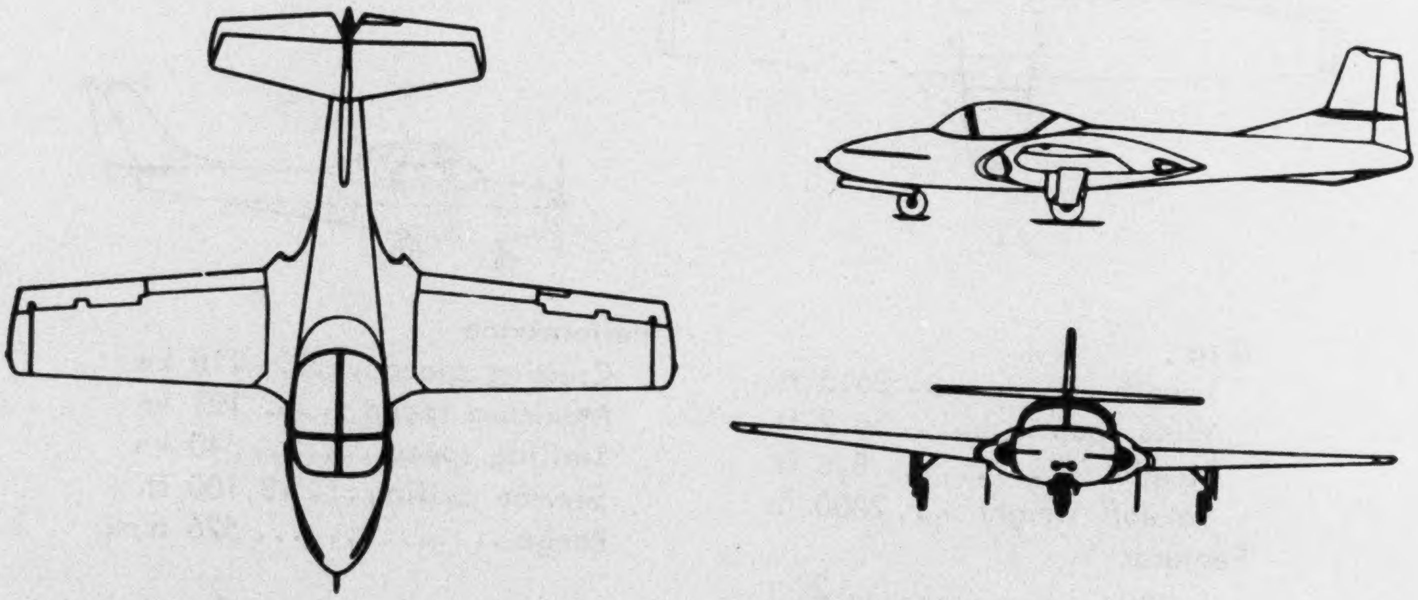
Fig. 3—Profile and characteristics of the T-41 trainer

T-41 flight training is provided by a civilian contractor at an airport near each base. Students live on the base and are bussed daily to the contractor's site. The T-41 aircraft are owned by the Air Force but operated and maintained by the contractor. Quality control of both instruction and maintenance is assured through supervision by Air Force personnel.

Phase II Flight Training

During the 19½ weeks of Phase II training, the student pilot learns to fly according to military standards, procedures, and techniques. The 90 flying hours are divided into 55 hours of contact flying,* 21 hours of instrument training, 9 hours of navigation practice, and 5 hours of introduction to formation flying. After completion of this phase, the student pilot has experienced most aspects of modern military flying and is well along toward mastery of the basic flying skills.

The Phase II aircraft, the subsonic jet T-37, is described in Fig. 4. It is commonly known as the "tweety bird" or "dog whistle" because of the high-frequency scream produced by its two jet engines.



Size	
Length	29.3 ft
Wing span	33.8 ft
Height	9.4 ft
Takeoff weight	6580 lb
Features	
Crew	2
Seating	side-by-side

Performance	
Cruising speed	297 kn
Maximum speed	352 kn
Stalling speed	74 kn
Service ceiling	35,500 ft
Range	500 n mi
Manufacturer	Cessna

Fig. 4—Profile and characteristics of the T-37 trainer

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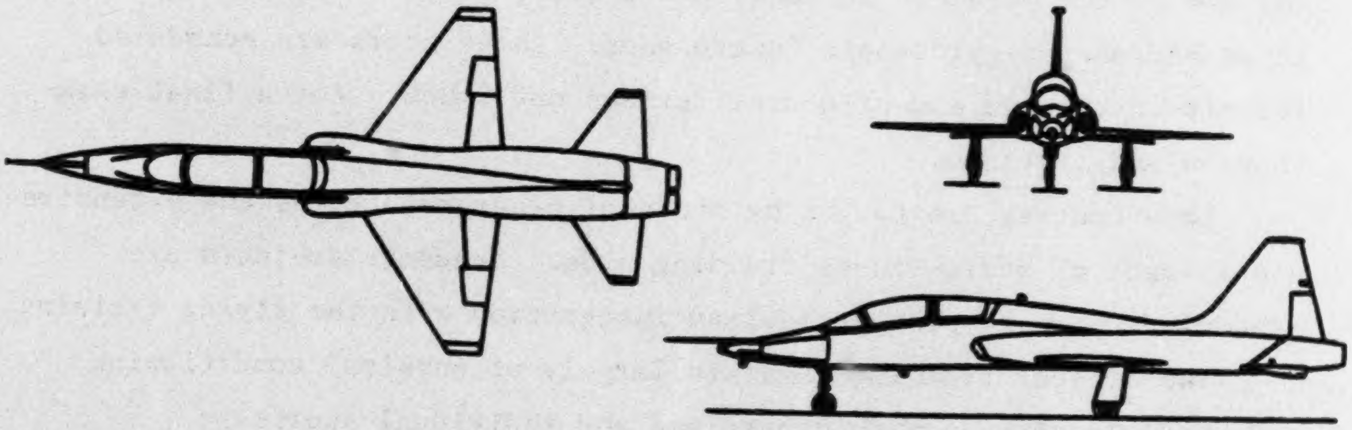
[*] Contact flying involves instruction in such fundamentals of flying as takeoffs, landings, turns, and climb and dive recoveries.

Air Training Command received the first such aircraft in 1956 and now operates over 700 of them. It has a cruising speed of 297 knots and a maximum speed at 352 knots.

UPT students are given 21 hours of instruction in the T-4 instrument trainer preliminary to their training in contact and instrument flying. The cockpit configuration and instrument indications simulate those of the T-37 aircraft. It is used initially to provide familiarity with the cockpit layout, especially the location and indications of the instruments. Later, instrument instruction flights are "flown" in the T-4 before they are flown in the aircraft.

Phase III Flight Training

During the 26-week final phase, the student pilots master flying skills learned in Phase II. The Phase III instruction is in a high-performance, supersonic aircraft--the Northrop T-38, described in Fig. 5. The T-38 cruises at just over 500 knots and can exceed Mach 1.2 in level flight. It is a relatively small aircraft, but its performance



Size		Performance	
Length (with nose boom)	46.3 ft	Cruise speed	502 kn
Wing span	25.3 ft	Maximum speed	715 kn
Height	12.9 ft	Stalling speed	148 kn
Takeoff weight	11,761 lb	Service ceiling	42,800 ft
Features		Range	875 n mi
Crew	2		
Seating	tandem	Manufacturer	Northrop

Fig.5—Profile and characteristics of the T-38 trainer

and flight characteristics duplicate closely those of modern tactical aircraft such as the F-4. ATC now operates over 900 T-38s.

The 120 hours of T-38 flying is divided into four segments: 37 hours of contact flying, 30 hours of instrument training, 16 hours of navigation practice, and 36 hours of formation flying.

In addition to flying, students receive 24 hours of training in the T-7/T-26 instrument trainer. It duplicates instrument characteristics of the T-38, just as the T-4 does for the T-37.

Academic and Officer Training

Table 5 lists 13 courses to which approximately 290 hours of UPT academic instruction is devoted.

Each course is divided into specific units of instruction with specific time allowances for each unit. For example, Flight Instruments, a 13-hour course given in Phase II, includes a 1-hour introduction to flight instruments, 3 hours' instruction in operation and interpretation of differential pressure instruments, 1 hour on the construction and use of the magnetic compass, and 3 hours on the construction, operation and use of gyroscopic instruments. Three hours are scheduled for mid-course and end-of-course reviews and 2 hours for a final examination and critique.

Many courses are taught by means of programmed texts and extensive use is made of audio-visual training aids. Academic subjects are scheduled so as to provide maximum integration with the flying training.

The officer training consists largely of physical conditioning and participation in both supervised and individual sports.

COMPARISON OF AIR FORCE AND NAVY UNDERGRADUATE PILOT TRAINING

The Navy is the only other United States service that conducts undergraduate jet pilot training. The United States Army has no jet aircraft in its inventory.

A comparison of the Navy and Air Force UPT programs shows some interesting similarities and differences.

The common objective of both programs is to enable a student who has had no flying experience to become a jet-qualified pilot. All Air Force UPT students must be commissioned officers; the Navy, through its Aviation Officer Candidate program, accepts students who have had no military experience.

The Navy course can be divided into three parts, roughly corresponding to the three phases of the Air Force course. The first part contains flight preparation, land and sea survival,* and primary flight training in the T-34. The second part is basic flight training in the T-2; the third is advanced flight training in the TF-9. A summary of the two courses is shown in Table 6. The Navy course contains 40 more

Table 6

COMPARISON OF AIR FORCE AND NAVY UPT COURSES

	Air Force	Navy
Training Aircraft		
Training phase[a]		
First	T-41	T-34
Second	T-37	T-2
Third	T-38	TF-9
Flying Hours		
Training phase[a]		
First	30	26
Second	90	114
Third	120	140
Total	240	280
Instrument trainer hours	45	39
Academic training hours	289	364
Officer training hours	172	42
Course duration (weeks)	53	60

[a] The Air Force designates the flying training phases as Phases I, II, and III. The Navy refers to them as Preflight/Survival/Primary, Basic, and Advanced.

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* The Air Force gives survival training to all flight crew members at Fairchild AFB, Washington, but it is not a part of the UPT program.

flying hours than provided by the Air Forcd UPT program. The Air Force course emphasizes flight fundamentals only, whereas the Navy incorporates some operational training in its UPT course.*

Unlike the Air Force, the Navy uses different installations for different phases of the training. The Navy student receives preflight, primary, and survival training at Pensacola Naval Air Station (NAS), Florida. He then moves to Meridian Naval Auxiliary Air Station (NAAS), Mississippi for the first part of basic training. From Meridian, he travels back to Pensacola NAS for the remainder of basic training including four weeks of gunnery and carrier qualifications. He then makes another move to one of the several Naval air stations in the Corpus Christi, Texas, area for advanced training.

Another significant difference is that the Air Force uses civilian flight instructors for the entire T-41 (primary) phase of its UPT program, whereas in the Navy program all flight instruction is given by military personnel.

A further difference between Navy and Air Force is found in the extent to which UPT graduates, with no pilot experience other than as a student, are used as instructor pilots. Currently, 45 percent of Air Force UPT instructor pilots are recent UPT graduates (first-tour pilots). Their normal tour of duty as an instructor is four years. The Navy uses fewer recent graduates and normally for a tour of only one year.

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*The Navy UPT course includes 45.4 flying hours for tactics and weapons, and 22.5 flying hours for carrier qualifications.

III. GENERAL DESCRIPTION OF THE UPT MODEL

In this section, a general description of the UPT model is presented. Specific areas discussed are the overall design of the model, cost-estimating concepts inherent in the model, desirable features of the model, and some of its limitations.

OVERALL DESIGN

The UPT model may be described as a simulation model. The model simulates the training program as it is described by inputs supplied by the user of the model. The inputs consist of quantitative information such as UPT graduate requirements, course syllabus requirements, instructor-student ratios, numbers of aircraft available, and cost relationships. Given these inputs, the model computes the manpower, equipment and facilities required for the UPT training. The model then calculates the costs associated with these requirements.

The model employs parametric estimating relationships. These relationships are used to estimate resources from such system parameters as numbers of instructors, flying hours, or students. An example of an estimating relationship is the cost of aircraft maintenance materials as a function of the number of flying hours. Such a relationship expresses the average situation as it appeared in history, and as it is projected into other situations. Although these relationships may not be appropriate for short-range management models, they are appropriate for long-range planning tools such as the UPT model.

The use of estimating relationships requires that the functional forms of the relationships be built into the computer model. The relationship between aircraft maintenance materials cost and the number of flying hours serves as an example. The Air Force has determined,* from historical data, that the cost of aircraft maintenance materials is best estimated as a function of the number of flying hours[*] and that the function is linear. For this reason, the computer program calculates the estimated aircraft maintenance materials cost by multiplying the number of flying hours by the materials cost per flying hour for the particular aircraft. This cost factor is specified by the user of the model as an input. Thus, if the materials cost per flying hour changes, the user specifies the new value. However, the underlying functional relationship, which requires that the material costs be calculated as a linear function of the number of flying hours, is built into the model and cannot be changed by the user.

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*Air Force Manual 172-3, USAF Cost and Planning Factors, April 1969 (Confidential). The portion cited is unclassified.

RESOURCE CATEGORIES

Three types of resources are identified: manpower, equipment, and facilities. Manpower includes the flight, simulator, academic and military training instructors; maintenance personnel for the aircraft and simulators; administrative personnel; and those who perform supply, transportation, medical, facilities-maintenance, and other base-support functions. Equipment includes aircraft, simulators, and auxiliary training equipment, aerospace ground equipment (AGE)[**] and base-support equipment. Facility items explicitly recognized are runways, simulator areas, classrooms, airmen dormitories, bachelor officer quarters (BOQ), and family housing.

COST CONCEPTS

The model incorporates three costing principles or concepts that are basic to most military costing studies. One important concept is the idea of analysis based on incremental costs. Another is that all categories of costs must be included in the incremental cost computations. Also, the model does not provide for any cost amortizations.

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[*] Rather than as a function of some other parameter such as number of sorties or number of aircraft on hand.

[**] AGE is testing and handling equipment used in aircraft maintenance and refueling.

Incremental Costs

All costs computed by the model are incremental to costs already incurred. The main purpose of the model is not to compute costs that already have been incurred as the consequence of past actions. Instead, the principal purpose is to provide a means of estimating the long-range impact of alternative policies and conditions or, stated differently, the effect future decisions will have on costs. For that reason, the output of the model does not show, for example, the cost of aircraft already procured.

Inclusion of Total Costs

The model is designed to reflect total resources and costs; that is, any resources used and, consequently, any costs incurred for UPT are included. For example, costs of depot maintenance of training aircraft are included, although such costs are not funded through Air Training Command. Also, if a new training aircraft is procured, the cost of that investment is shown.

Cost Amortizations

Costs in the UPT model are not amortized. Amortization refers to spreading capital costs over a number of years, usually over the years the capital item is expected to be used. Instead, the UPT model reports the entire investment cost in the year in which the capital item is delivered. Thus, if a new training aircraft is introduced into UPT, the procurement cost for each aircraft is reported in the year in which the aircraft is delivered. It follows that if one looks at the costs only for the year in which the procurement is made, the cost per graduate may appear abnormally high.

Capital costs are not amortized within the model for two reasons. First, showing the cost of capital items in the year in which the items are delivered gives a useful approximation of the time when the funds would actually be spent. When considering a new UPT program with large expenditures for equipment, estimating the timing of costs can be very important. Second, it would be difficult to build into the model an amortization scheme that would satisfy all users. Once the user obtains the annual costs reported by the model, he may apply, manually, any amortization rule he desires. For example, the long-run effect of a procurement of training aircraft can be obtained by manually computing the average cost per graduate over the useful life of the aircraft.

FLEXIBILITY OF INPUTS

The user of the UPT model is given wide latitude in varying input data to define the training program the model is to simulate. Nearly any training syllabus that one may hypothesize may be entered as an input. New training aircraft and simulators may be assumed; and any number of flying, simulator, academic, and officer training hours may be used as inputs. Also, the rate at which a student can learn, which in part determines the length of each phase of training, may be varied. Moreover, the mix of the training that is accomplished at each training base may be varied. For example, one may test the impact of teaching phases I and II on one base and III on another.

Also, the model uses many non-training parameters. These are variables that affect resources and costs of training but are not directly related to training policy. One such parameter is the aircraft base maintenance personnel requirement per flying hour. By varying such parameters, the user may test the impact of policies related indirectly as well as directly to training.

The model accepts separate inputs for each phase of training, each UPT base, and each year. In most cases, calculations are performed by phase, base, and year.* The user may vary the number of phases, bases, and years. For example, a UPT course consisting of only two phases may be used.

The input procedure is made simple because the user need specify only those inputs that change from one year to the next within a single computer run. Also, when entering inputs for a new computer run, only the input values that vary from the previous run need be changed.

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*It is important to differentiate between these cost computations by phase, base, and year, on one hand, and the multiplication, for example, of one year's training costs by the number of years modeled, on the other.

"PREFERENCE LIST" FEATURE

The training capacity of the UPT system is explicitly considered. The user is allowed to increase the training capacity in any year by specifying additional runways, airspace, or training bases. In addition, the user may use a "preference list" for additional capacity, that is, he may incorporate a list specifying, sequentially, the steps by which the required additional capacity is to be attained. This list is used as follows: For each year, the model computes the training capacity and compares this with the student load. If the training capacity is insufficient in any given year, additions are made from the preference list in the order specified. For example, the first choice might be the addition of a runway. If capacity is still insufficient, the second choice would be added, and so on, until either the capacity is adequate or the preference list becomes exhausted, in which latter case an error message is printed.

"AUTOMATIC RESPONSE" FEATURE

The model is constructed so that it responds automatically to resource requirements; that is, automatically fills any shortages in personnel, aircraft, simulators, classrooms, and space for simulators. For example, if the inventory of aircraft in any year is insufficient, the model assumes that additional aircraft are to be purchased and the appropriate procurement costs are incurred. If the user did not wish to have training aircraft purchased, he then may make another computer run after changing an appropriate input, say, for example, the aircraft utilization rate.

Provisions in the model for these kinds of automatic responses to needed increases in resources enable the user to obtain as much information as possible from a given run before introducing different inputs for a new one.

LIMITATIONS

The following variables are limited in their ranges of values: The number of training phases is between 1 and 3, the number of bases between 1 and 15, and the number of years between 1 and 20. The UPT course length is limited to two years.

The model is constructed to simulate the training program specified by the user. It is a deterministic model rather than an optimization model and, hence, it does not provide an optimum choice, specified by the user, such as minimum training costs. An example of this limitation is the manner in which the model responds to the preference list routine for adding capacity. If the first of the specified preferences is to add a base, it will be added even though additional capacity is needed for only one student. In this and other such cases, the model will not attempt to choose the optimum course of action. Instead, it simulates whatever courses of action the user specifies.

Another limitation concerns the averaging of values. Because the UPT model was developed for long-range planning, it operates in yearly increments. For this reason, many variables of the model are yearly averages. Although student strength may vary throughout a given year, the model computes only the average number of students undergoing training during the year.*

Still another type of limitation concerns the manner in which some data are aggregated. The aggregated data include cost as well as resources. For example, the element of cost that the model identifies as Supplies and Services is estimated in total even though it includes such diverse items as refuse collection, electricity and gas, and food service. Similarly, the manning required for an air base group is estimated in total without identifying the personnel by function (for example, transportation, air police, supply, and civil engineering).

Limitations also result from the use of estimating relationships. Their use does not result in precise estimates of resources or costs even though accurate data are used to determine the relationship. The possibility of obtaining an erroneous estimate is greater if extrapolations are made beyond the range of the data from which the estimating relationship was derived. For example, the relationship of the number of aircraft maintenance personnel required per flying hour was developed from UPT flying experience accumulated in previous years. This might not be a good predictor if the level of flying were greatly increased. This limitation should be recognized because the functional forms of the relationships are built into the model and cannot be changed by the user.

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*The average number of students undergoing training during a given year is generally referred to as the "student load."

IV. USES OF THE UPT MODEL

This section describes how the UPT model is used. First, its uses, both as an independent model and as one of the series of models developed in the Pilot Training Study, are described. Next, an example is shown in which all the output tables of the model are presented. Finally, the use of the model as a tool for sensitivity analysis is discussed.

INDEPENDENT USE AND USE WITH OTHER MODELS

The UPT model may be used in two ways. It may be used independently to examine alternative ways to conduct UPT. It also may be used in conjunction with the PILOT, APT, and Survival School models (and with the cost-estimating methodology that is provided for estimating precommissioning training costs) to estimate the overall impact of pilot training alternatives.

When the models are used in combination, they are driven by inputs obtained from the PILOT model. When this is done, the combined models integrate the individual training programs into a simulation of the entire formal training process. The PILOT model calculates the flows of students through each training activity based on inputs specifying such things as the number of pilots required in cockpit positions, pilot retention rates, student attrition rates, and training times. These student flows are entered as inputs into the respective resource and cost models to determine their impact. In this way, interrelationships among the various training activities are explicitly considered. For example a decrease in the amount of cross-training of pilots from desks to cockpits may increase the requirement for pilots to be obtained from UPT. In turn, an increase in UPT production may require an increase in precommissioning training. The models, in combination, form a mechanism that may be used to estimate resources required for the various training activities and the total cost of formal pilot training.

On the other hand, the UPT model may be used independently to examine UPT alternatives while ignoring their effects on other training activities. For instance, one may be interested only in the effect that a lengthening of the UPT training period would have on UPT course costs. If the UPT course were lengthened by increasing the syllabus flying hour requirement, the UPT model would show the many effects upon undergraduate pilot training. That is, if the graduate requirement were to remain the same, the student load would have to be increased. Then, more flying hours would be logged each year and more flight instructors and maintenance personnel would be required. Possibly additional aircraft would be needed, and procurement costs would be incurred. Also, the additional personnel would increase pay and training costs.

ILLUSTRATIVE EXAMPLE

An illustrative example of how the model is used to estimate the resources and associated costs of a given UPT system is presented here. For ease of illustration, this example consists of a single UPT base examined over a three-year period. For long-range planning, however, the user must examine the entire UPT system (i.e., all of the training bases) over a longer period of time--perhaps 5 to 20 years.

Inputs are entered on standard 80-column punched cards. Volume V of the study describes how the input values are arranged on the cards.* (About 50 input cards were required for the example shown here, whereas about 250 would be required for a typical set of inputs for all UPT bases for 10 years.)

Identical inputs were entered for each year; results, therefore, are the same for each year. Output tables from this example are shown in Figs. 6 through 18 in the order in which the outputs are printed.

The first table of output, shown in Fig. 6, presents a summary of the total training capacity of all UPT bases. Because this example consists of one hypothetical base, only that base is reflected in the total.

Next, a table showing the capacity results for each base is printed. The table for the hypothetical base appears in Fig. 7. The results

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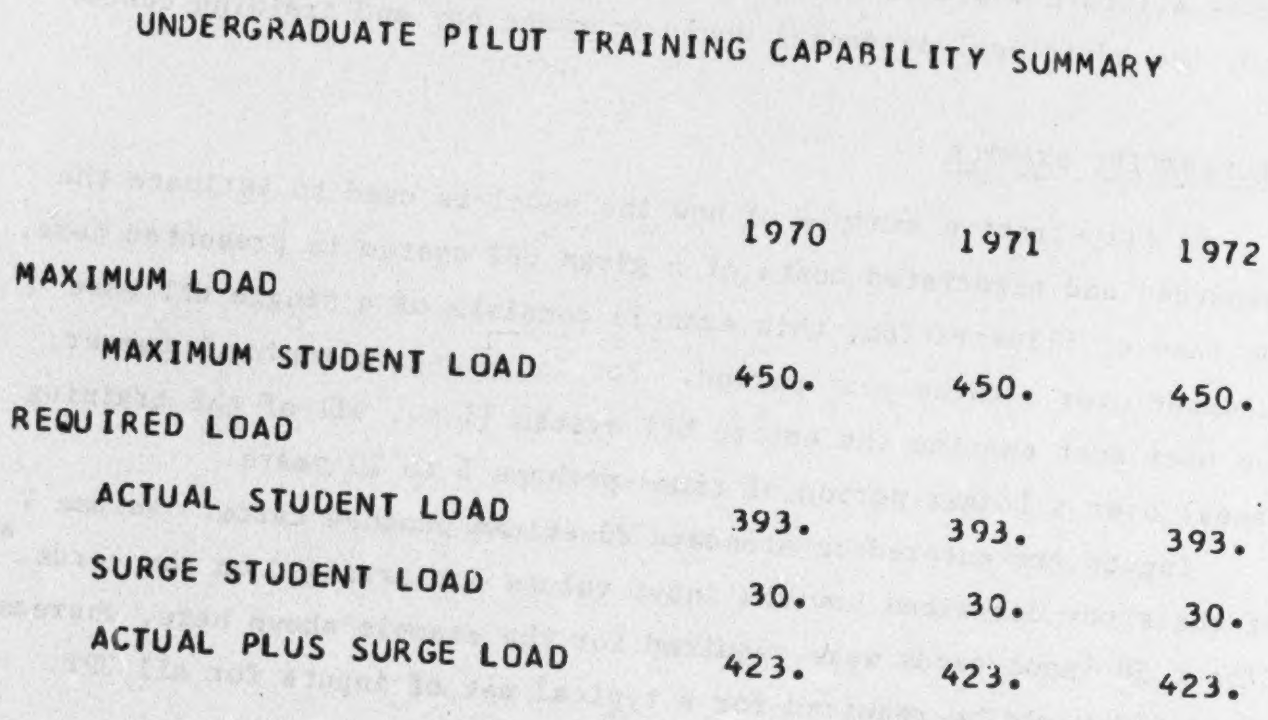
*See Preface.



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          UNDERGRADUATE PILOT TRAINING CAPABILITY SUMMARY


                                      1970       1971       1972
MAXIMUM LOAD

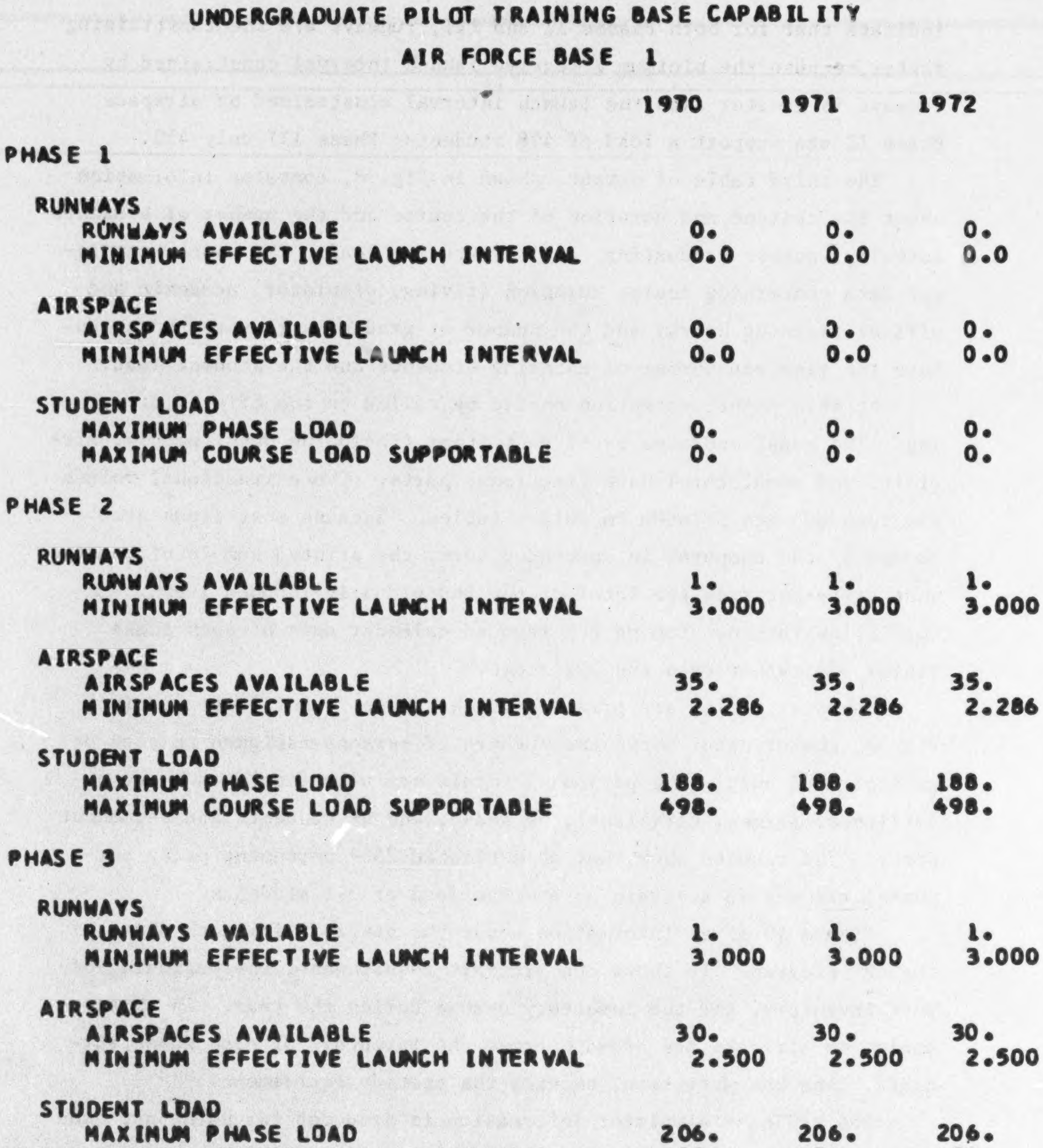
      MAXIMUM STUDENT LOAD            450.       450.       450.
REQUIRED LOAD

     ACTUAL STUDENT LOAD              393.       393.       393.

     SURGE STUDENT LOAD                30.        30.        30.

     ACTUAL PLUS SURGE LOAD           423.       423.       423.
```

Fig. 6—First page of output, showing UPT student load capacity in summary for all bases



```
                  UNDERGRADUATE PILOT TRAINING BASE CAPABILITY
                                AIR FORCE BASE  1
                                                  1970      1971      1972
PHASE 1

  RUNWAYS
     RUNWAYS AVAILABLE                              0.        0.        0.
     MINIMUM EFFECTIVE LAUNCH INTERVAL             0.0       0.0       0.0

  AIRSPACE
     AIRSPACES AVAILABLE                            0.        0.        0.
     MINIMUM EFFECTIVE LAUNCH INTERVAL             0.0       0.0       0.0

  STUDENT LOAD
     MAXIMUM PHASE LOAD                             0.        0.        0.
     MAXIMUM COURSE LOAD SUPPORTABLE                0.        0.        0.
PHASE 2

  RUNWAYS
     RUNWAYS AVAILABLE                              1.        1.        1.
     MINIMUM EFFECTIVE LAUNCH INTERVAL           3.000     3.000     3.000

  AIRSPACE
     AIRSPACES AVAILABLE                           35.       35.       35.
     MINIMUM EFFECTIVE LAUNCH INTERVAL           2.286     2.286     2.286

  STUDENT LOAD
     MAXIMUM PHASE LOAD                           188.      188.      188.
     MAXIMUM COURSE LOAD SUPPORTABLE              498.      498.      498.

PHASE 3

  RUNWAYS
     RUNWAYS AVAILABLE                              1.        1.        1.
     MINIMUM EFFECTIVE LAUNCH INTERVAL           3.000     3.000     3.000

  AIRSPACE
     AIRSPACES AVAILABLE                           30.       30.       30.
     MINIMUM EFFECTIVE LAUNCH INTERVAL           2.500     2.500     2.500

  STUDENT LOAD
     MAXIMUM PHASE LOAD                           206.      206.      206.
     MAXIMUM COURSE LOAD SUPPORTABLE              450.      450.      450.

COURSE

  MAXIMUM STUDENT LOAD                            450.      450.      450.
  ACTUAL STUDENT LOAD                             393.      393.      393.
```

Fig. 7—Second page of output showing UPT capacity for AFB 1

indicate that for both Phases II and III, runways are the constraining factor because the minimum effective launch interval constrained by runways is greater than the launch interval constrained by airspace. Phase II can support a load of 498 students; Phase III only 450.

The third table of output, shown in Fig. 8, contains information about the content and duration of the course and the number of students entering, number graduating, and the student load. The model uses input data concerning course duration (flying, simulator, academic and officer training hours) and the number of graduates required to calculate the required number of entering students and the student load.

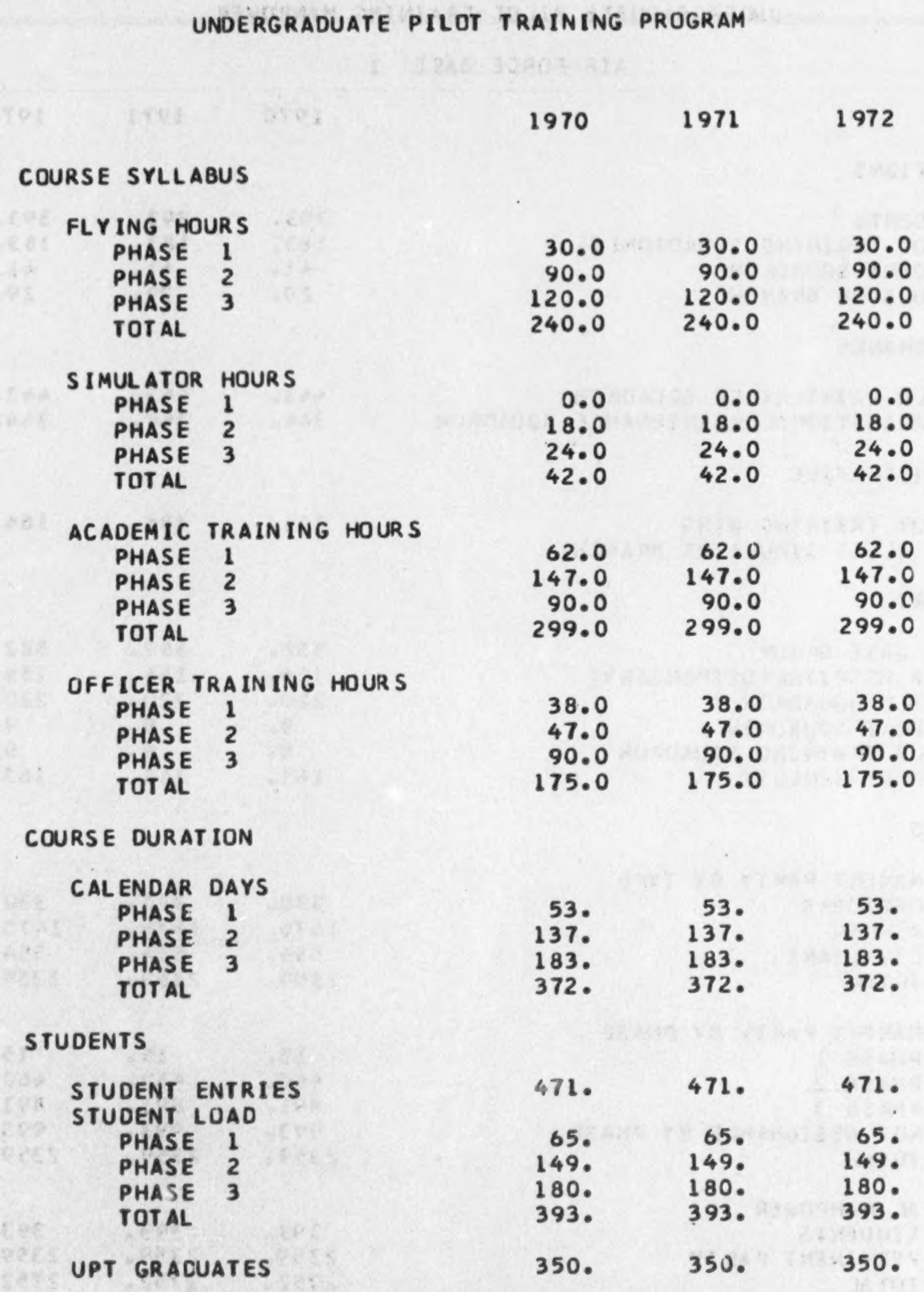
At this point, attention should be called to the effects of rounding. The model operates as if most items (including days, people, aircraft, and simulators) have fractional parts. These fractional values are rounded when printed in output tables. Because most items are summed by the computer in unrounded form, the printed sum is often somewhat different from the total of the individually rounded items. In this illustration, summing the rounded calendar days of each phase yields 373 rather than the 372 shown.

Manpower tables are printed for each base. As illustrated in Fig. 9, the printout shows the numbers of persons assigned to each organizational unit. The personnel totals are also displayed by type (officers, airmen, civilians), by phase, and by students and permanent party. The results show that an estimated 2359 permanent party personnel are needed to train an average load of 393 students.

Figure 10 gives information about the aircraft for each phase of the UPT program. It shows the aircraft requirement, the beginning-of-year inventory, and the inventory change during the year. In this example, no aircraft are added because the inventory of each phase aircraft, less the attrition, exceeds the stated requirement.

One table of simulator information is produced for each base (see Fig. 11). It is similar to the aircraft table, except that attrition does not apply.

The remaining tables present the costs of the UPT program. Since these are only illustrative examples, the costs are hypothetical and should not be taken to be estimates of the present program.



```
                    UNDERGRADUATE PILOT TRAINING PROGRAM

                                         1970       1971       1972

  COURSE SYLLABUS

     FLYING HOURS
        PHASE  1                          30.0       30.0       30.0
        PHASE  2                          90.0       90.0       90.0
        PHASE  3                         120.0      120.0      120.0
        TOTAL                            240.0      240.0      240.0

     SIMULATOR HOURS
        PHASE  1                           0.0        0.0        0.0
        PHASE  2                          18.0       18.0       18.0
        PHASE  3                          24.0       24.0       24.0
        TOTAL                             42.0       42.0       42.0

     ACADEMIC TRAINING HOURS
        PHASE  1                          62.0       62.0       62.0
        PHASE  2                         147.0      147.0      147.0
        PHASE  3                          90.0       90.0       90.0
        TOTAL                            299.0      299.0      299.0

     OFFICER TRAINING HOURS
        PHASE  1                          38.0       38.0       38.0
        PHASE  2                          47.0       47.0       47.0
        PHASE  3                          90.0       90.0       90.0
        TOTAL                            175.0      175.0      175.0

  COURSE DURATION

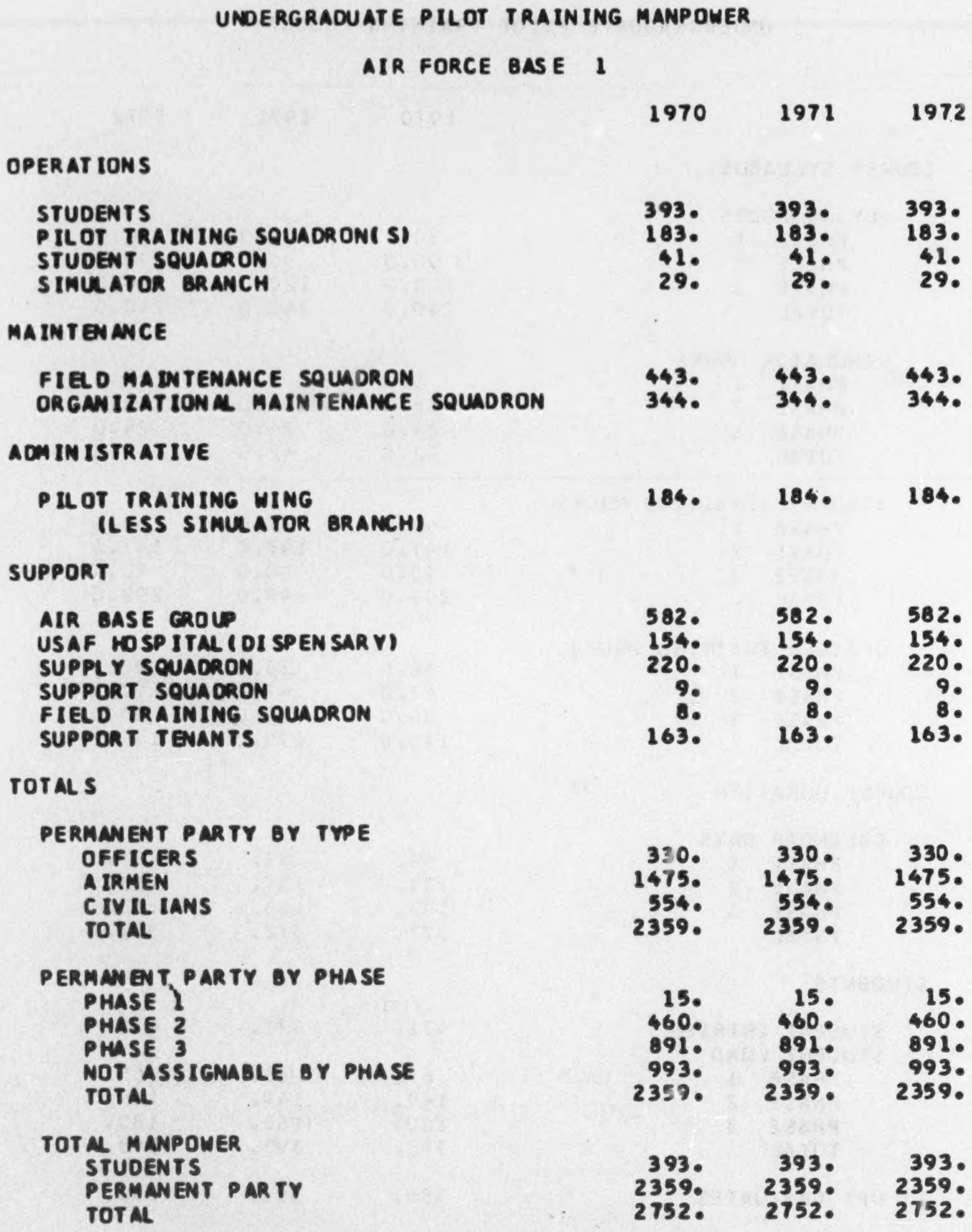
     CALENDAR DAYS
        PHASE  1                          53.        53.        53.
        PHASE  2                         137.       137.       137.
        PHASE  3                         183.       183.       183.
        TOTAL                            372.       372.       372.

  STUDENTS

     STUDENT ENTRIES                     471.       471.       471.
     STUDENT LOAD
        PHASE  1                          65.        65.        65.
        PHASE  2                         149.       149.       149.
        PHASE  3                         180.       180.       180.
        TOTAL                            393.       393.       393.

     UPT GRADUATES                       350.       350.       350.
```

Fig.8—Third page of output, showing UPT syllabus, course duration and numbers of students for all bases, by training phase



```
                    UNDERGRADUATE PILOT TRAINING MANPOWER

                              AIR FORCE BASE  1

                                                  1970      1971      1972

OPERATIONS

   STUDENTS                                       393.      393.      393.
   PILOT TRAINING SQUADRON(S)                     183.      183.      183.
   STUDENT SQUADRON                                41.       41.       41.
   SIMULATOR BRANCH                                29.       29.       29.

MAINTENANCE

   FIELD MAINTENANCE SQUADRON                     443.      443.      443.
   ORGANIZATIONAL MAINTENANCE SQUADRON            344.      344.      344.

ADMINISTRATIVE

   PILOT TRAINING WING                            184.      184.      184.
       (LESS SIMULATOR BRANCH)

SUPPORT

   AIR BASE GROUP                                 582.      582.      582.
   USAF HOSPITAL(DISPENSARY)                      154.      154.      154.
   SUPPLY SQUADRON                                220.      220.      220.
   SUPPORT SQUADRON                                 9.        9.        9.
   FIELD TRAINING SQUADRON                          8.        8.        8.
   SUPPORT TENANTS                                163.      163.      163.

TOTALS

   PERMANENT PARTY BY TYPE
      OFFICERS                                    330.      330.      330.
      AIRMEN                                     1475.     1475.     1475.
      CIVILIANS                                   554.      554.      554.
      TOTAL                                      2359.     2359.     2359.

   PERMANENT PARTY BY PHASE
      PHASE 1                                      15.       15.       15.
      PHASE 2                                     460.      460.      460.
      PHASE 3                                     891.      891.      891.
      NOT ASSIGNABLE BY PHASE                     993.      993.      993.
      TOTAL                                      2359.     2359.     2359.

   TOTAL MANPOWER
      STUDENTS                                    393.      393.      393.
      PERMANENT PARTY                            2359.     2359.     2359.
      TOTAL                                      2752.     2752.     2752.
```

Fig. 9—Fourth page of output showing UPT manpower requirements for AFB 1

```
             UNDERGRADUATE PILOT TRAINING AIRCRAFT

                                    1970       1971       1972
   REQUIREMENT
        PHASE 1                     14.9       14.9       14.9
        PHASE 2                     58.7       58.7       58.7
        PHASE 3                     73.9       73.9       73.9

   INVENTORY (BEGINNING OF YEAR)
        PHASE 1                     20.0       19.7       19.5
        PHASE 2                     60.0       59.6       59.1
        PHASE 3                     80.0       78.5       77.0

   ADDITIONS BY USER (DURING YEAR)
        PHASE 1                      0.0        0.0        0.0
        PHASE 2                      0.0        0.0        0.0
        PHASE 3                      0.0        0.0        0.0

   ADDITIONS BY MODEL (DURING YEAR)
        PHASE 1                      0.0        0.0        0.0
        PHASE 2                      0.0        0.0        0.0
        PHASE 3                      0.0        0.0        0.0

   LOSSES FROM ATTRITION
            (DURING YEAR)
        PHASE 1                      0.3        0.3        0.3
        PHASE 2                      0.4        0.4        0.4
        PHASE 3                      1.5        1.5        1.5
```

Fig. 10—Fifth page of output showing UPT aircraft requirements for all bases

```
                UNDERGRADUATE PILOT TRAINING SIMULATORS

                         AIR FORCE BASE  1

                                     1970        1971        1972

REQUIREMENT
     PHASE 1                          0.0         0.0         0.0
     PHASE 2                          4.8         4.8         4.8
     PHASE 3                          5.8         5.8         5.8

INVENTORY (BEGINNING OF YEAR)
     PHASE 1                          0.0         0.0         0.0
     PHASE 2                          7.0         7.0         7.0
     PHASE 3                          9.0         9.0         9.0

ADDITIONS BY USER (DURING YEAR)
     PHASE 1                          0.0         0.0         0.0
     PHASE 2                          0.0         0.0         0.0
     PHASE 3                          0.0         0.0         0.0

ADDITIONS BY MODEL (DURING YEAR)
     PHASE 1                          0.0         0.0         0.0
     PHASE 2                          0.0         0.0         0.0
     PHASE 3                          0.0         0.0         0.0
```

Fig. 11—Sixth page of output showing UPT simulator requirements for AFB 1

Figure 12 shows the costs for the sample base. Costs are shown for each cost element, then totalled by type (investment and operating) and phase.

Next, the costs that are not allocated to any one of the bases are presented in a table. The unallocated costs consist mainly of RDT&E and aircraft investment costs as depicted in Fig. 13. These costs are all zero in this example.

Costs are then shown by phase: Figure 14 (Phase I), Fig. 15 (Phase II), and Fig. 16 (Phase III). Figure 17 shows the costs not allocated to any phase, i.e., the costs of operating non-training aircraft and of the fixed manpower requirements.

Finally, a cost summary, shown in Fig. 18, is printed. It presents totals by type (RDT&E), investment, operating), phase, and base.

SENSITIVITY ANALYSIS

Much can be learned by examining how the results of the computations of the model vary as a given input value is varied. Analysis of this sort is generally referred to as sensitivity analysis.

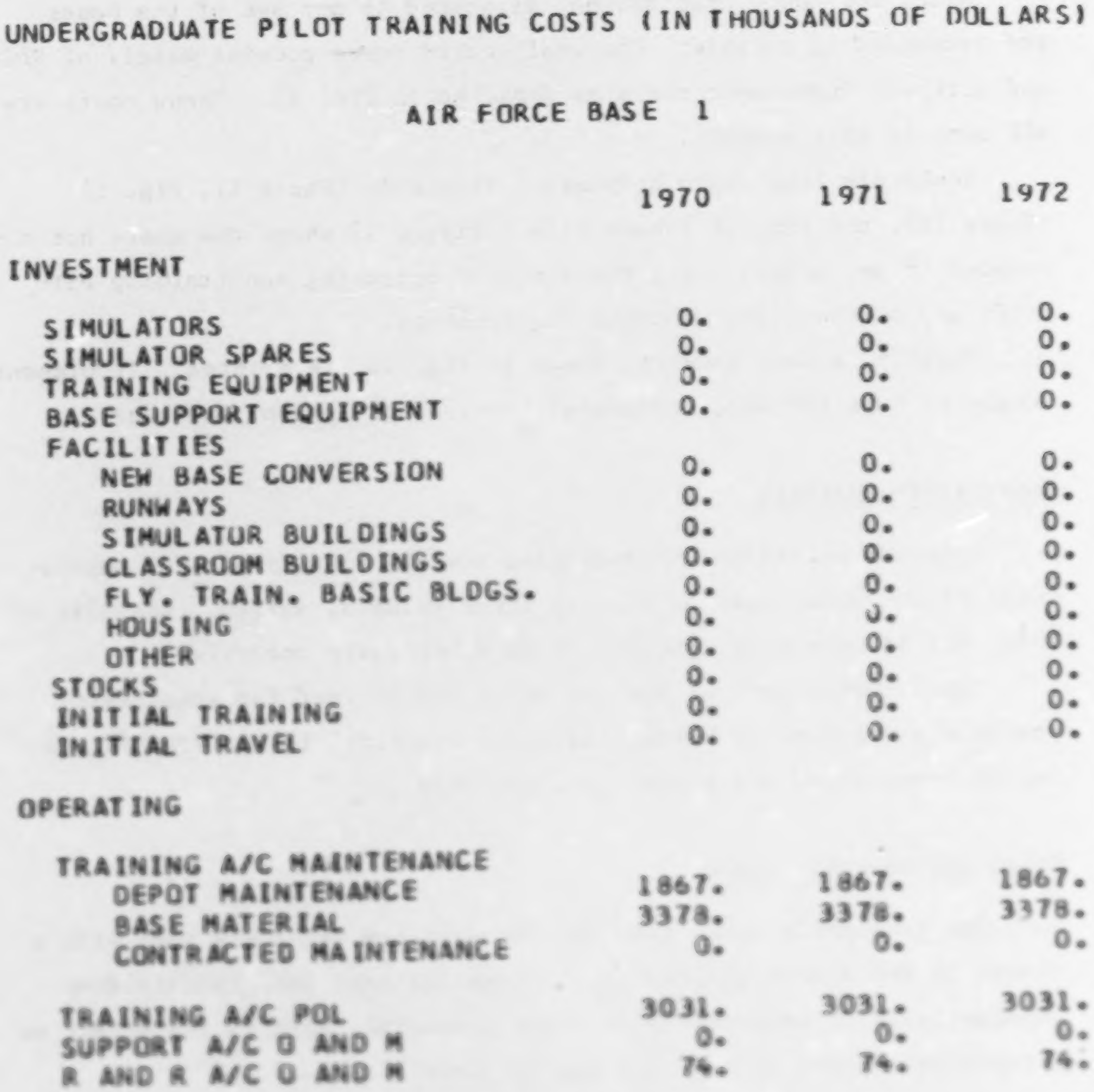
Two illustrations of how the model can be used for sensitivity analysis are presented below. In these examples, the entire UPT system is considered, and actual data are used.

Fixed and Variable Costs

One frequently-asked question concerns how UPT costs vary with a change in the number of graduates: Does the cost per graduate drop substantially if many more pilots are produced? What is the effect on per-graduate costs of adding a new UPT base?

The model was exercised repeatedly with all inputs remaining unchanged except that the annual graduate requirement was varied from 3100 to 5200.

It was assumed that sufficient equipment and facilities (including aircraft and training bases) were available to produce up to 5200 graduates a year. The availability of equipment and facilities for UPT depends on the particular circumstances that exist within the Air



```
UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)

                      AIR FORCE BASE  1

                                     1970        1971        1972

INVESTMENT

  SIMULATORS                           0.          0.          0.
  SIMULATOR SPARES                     0.          0.          0.
  TRAINING EQUIPMENT                   0.          0.          0.
  BASE SUPPORT EQUIPMENT               0.          0.          0.
  FACILITIES
     NEW BASE CONVERSION               0.          0.          0.
     RUNWAYS                           0.          0.          0.
     SIMULATUR BUILDINGS               0.          0.          0.
     CLASSROOM BUILDINGS               0.          0.          0.
     FLY. TRAIN. BASIC BLDGS.          0.          0.          0.
     HOUSING                           0.          0.          0.
     OTHER                             0.          0.          0.
  STOCKS                               0.          0.          0.
  INITIAL TRAINING                     0.          0.          0.
  INITIAL TRAVEL                       0.          0.          0.

OPERATING

  TRAINING A/C MAINTENANCE
     DEPOT MAINTENANCE              1867.       1867.       1867.
     BASE MATERIAL                  3378.       3378.       3378.
     CONTRACTED MAINTENANCE            0.          0.          0.

  TRAINING A/C POL                  3031.       3031.       3031.
  SUPPORT A/C O AND M                  0.          0.          0.
  R AND R A/C O AND M                 74.         74.         74.
```

Fig. 12—Seventh and eighth pages of output showing UPT costs for AFB 1

	1970	1971	1972
OPERATING (CONTINUED)			
SIMULATOR MAT. AND SERVS.	26.	26.	26.
FACILITIES MAT. AND SERVS.	1379.	1379.	1379.
CONTRACTED FLYING TRAINING	264.	264.	264.
PAY AND ALLOWANCES			
OFFICERS	9760.	9760.	9760.
AIRMEN	8853.	8853.	8853.
CIVILIANS	4043.	4043.	4043.
TRAINING	1017.	1017.	1017.
TRAVEL	681.	681.	681.
SUPPLIES AND SERVICES	1099.	1099.	1099.
COST BY TYPE			
INVESTMENT	0.	0.	0.
OPERATING	35471.	35471.	35471.
TOTAL	35472.	35472.	35472.
COST BY PHASE			
PHASE 1	1315.	1315.	1315.
PHASE 2	8773.	8773.	8773.
PHASE 3	16027.	16027.	16027.
NOT ASSIGNABLE TO PHASE	9356.	9356.	9356.
TOTAL	35472.	35472.	35472.

Fig. 12—Continued

```
UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)
                   NOT ASSIGNABLE TO BASE


                                            1970       1971       1972

RDT AND E                                    0.         0.         0.
INVESTMENT

   TRAINING AIRCRAFT                         0.         0.         0.
   SUPPORT AIRCRAFT                          0.         0.         0.
   RESCUE AND RECOVERY A/C                   0.         0.         0.
   TRAINING A/C SPARES                       0.         0.         0.
   AEROSPACE GROUND EQUIP.                   0.         0.         0.

OPERATING

   RECURRING MODIFICATIONS                   0.         0.         0.

COST BY TYPE

   RDT AND E                                 0.         0.         0.
   INVESTMENT                                0.         0.         0.
   OPERATING                                 0.         0.         0.
   TOTAL                                     0.         0.         0.

COST BY PHASE

   PHASE 1                                   0.         0.         0.
   PHASE 2                                   0.         0.         0.
   PHASE 3                                   0.         0.         0.
   NOT ASSIGNABLE TO PHASE                   0.         0.         0.
   TOTAL                                     0.         0.         0.
```

Fig. 13—Ninth page of output, showing UPT costs not allocated to bases

```
UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)

                           PHASE 1

                                     1970       1971       1972

RDT AND E                              0.         0.         0.

INVESTMENT

   TRAINING AIRCRAFT                   0.         0.         0.
   SIMULATORS                          0.         0.         0.

   SPARES
      AIRCRAFT                         0.         0.         0.
      SIMULATOR                        0.         0.         0.

   AEROSPACE GROUND EQUIP.             0.         0.         0.
   TRAINING EQUIPMENT                  0.         0.         0.
   BASE SUPPORT EQUIPMENT              0.         0.         0.
   RUNWAYS                             0.         0.         0.
   STOCKS                              0.         0.         0.
   INITIAL TRAINING                    0.         0.         0.
   INITIAL TRAVEL                      0.         0.         0.

OPERATING

   RECURRING MODIFICATIONS             0.         0.         0.

   TRAINING A/C MAINTENANCE
      DEPOT MAINTENANCE                0.         0.         0.
      BASE MATERIAL                    0.         0.         0.
      CONTRACTED MAINTENANCE           0.         0.         0.

   TRAINING A/C POL                    0.         0.         0.
   SIMULATOR MAT. AND SERVS.           0.         0.         0.
   FACILITIES MAT. AND SERVS.         29.        29.        29.
   CONTRACTED FLYING TRAINING        264.       264.       264.

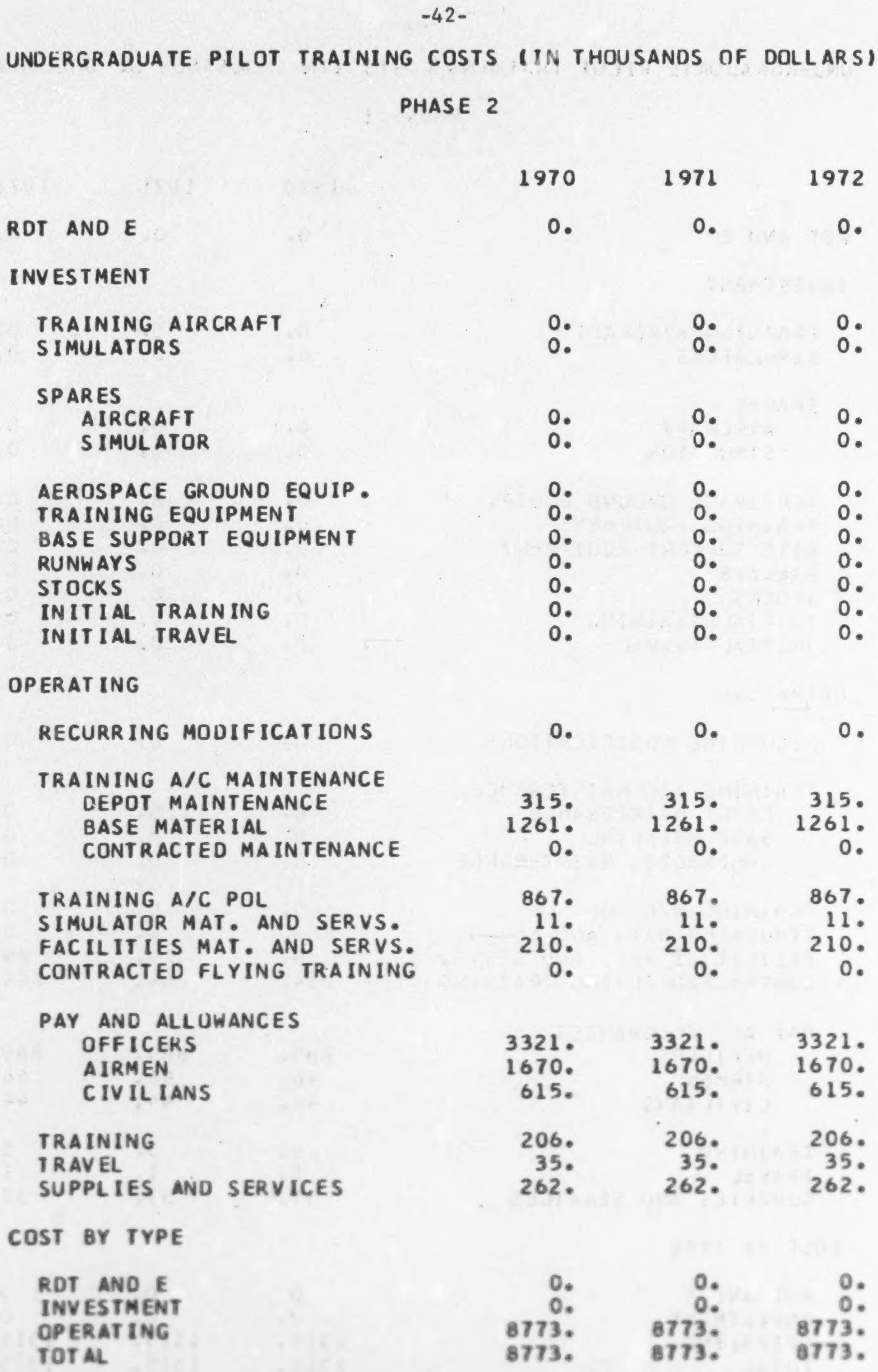
   PAY AND ALLOWANCES
      OFFICERS                       889.       889.       889.
      AIRMEN                          46.        46.        46.
      CIVILIANS                       44.        44.        44.

   TRAINING                            5.         5.         5.
   TRAVEL                              1.         1.         1.
   SUPPLIES AND SERVICES              37.        37.        37.

COST BY TYPE

   RDT AND E                           0.         0.         0.
   INVESTMENT                          0.         0.         0.
   OPERATING                        1315.      1315.       135.
   TOTAL                            1315.      1315.       135.
```

Fig. 14—Tenth page of output, showing UPT costs for training phse I



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                                   -42-

UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)

                                 PHASE 2

                                      1970        1971        1972

RDT AND E                               0.          0.          0.

INVESTMENT

  TRAINING AIRCRAFT                     0.          0.          0.
  SIMULATORS                            0.          0.          0.

  SPARES
     AIRCRAFT                           0.          0.          0.
     SIMULATOR                          0.          0.          0.

  AEROSPACE GROUND EQUIP.               0.          0.          0.
  TRAINING EQUIPMENT                    0.          0.          0.
  BASE SUPPORT EQUIPMENT                0.          0.          0.
  RUNWAYS                               0.          0.          0.
  STOCKS                                0.          0.          0.
  INITIAL TRAINING                      0.          0.          0.
  INITIAL TRAVEL                        0.          0.          0.

OPERATING

  RECURRING MODIFICATIONS               0.          0.          0.

  TRAINING A/C MAINTENANCE
     DEPOT MAINTENANCE                315.        315.        315.
     BASE MATERIAL                   1261.       1261.       1261.
     CONTRACTED MAINTENANCE             0.          0.          0.

  TRAINING A/C POL                    867.        867.        867.
  SIMULATOR MAT. AND SERVS.            11.         11.         11.
  FACILITIES MAT. AND SERVS.          210.        210.        210.
  CONTRACTED FLYING TRAINING            0.          0.          0.

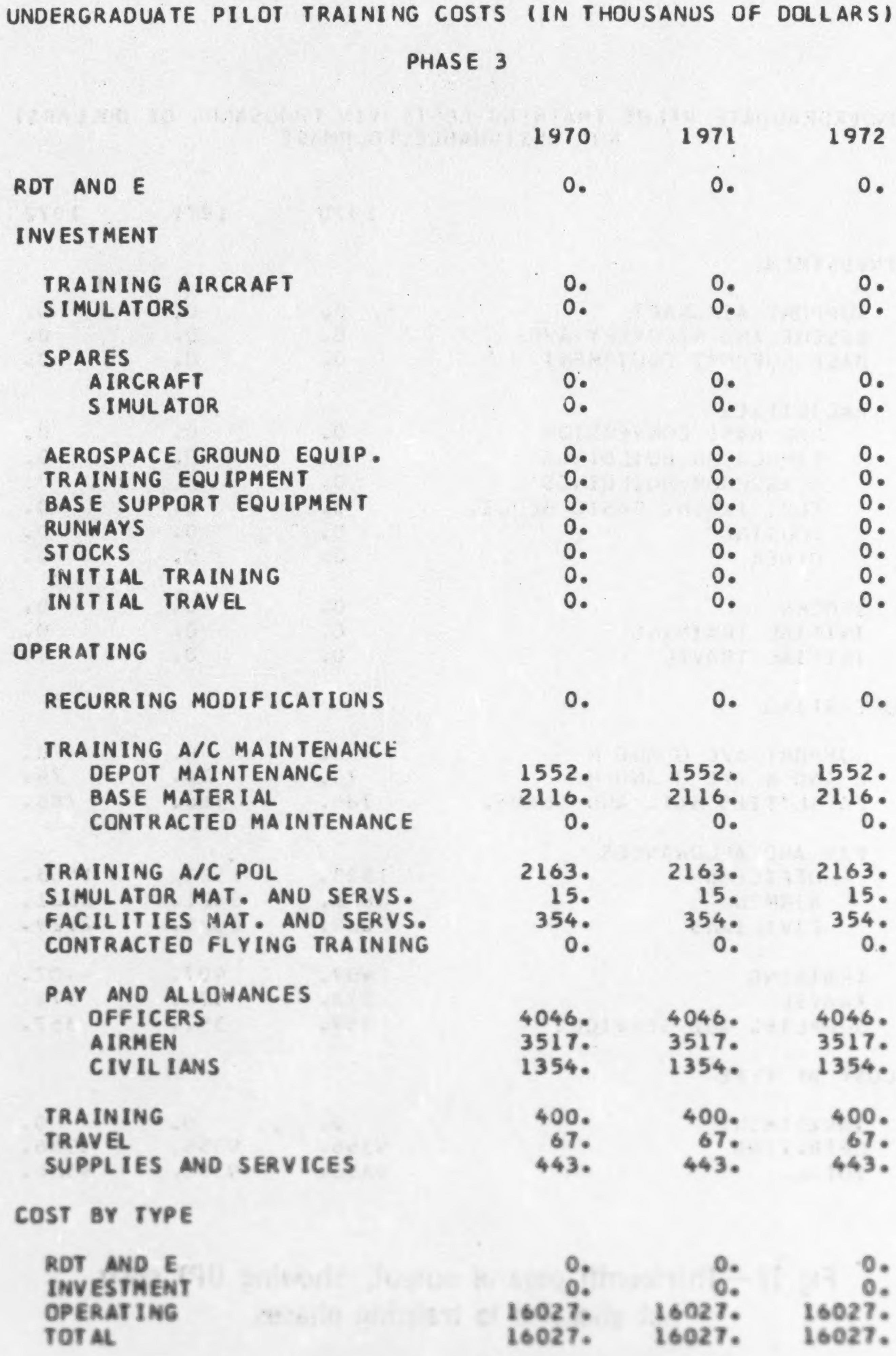
  PAY AND ALLOWANCES
     OFFICERS                        3321.       3321.       3321.
     AIRMEN                          1670.       1670.       1670.
     CIVILIANS                        615.        615.        615.

  TRAINING                            206.        206.        206.
  TRAVEL                               35.         35.         35.
  SUPPLIES AND SERVICES               262.        262.        262.

COST BY TYPE

  RDT AND E                             0.          0.          0.
  INVESTMENT                            0.          0.          0.
  OPERATING                          8773.       8773.       8773.
  TOTAL                              8773.       8773.       8773.
```

Fig. 15—Eleventh page of output, showing UPT costs for training phase II



```
UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)

                         PHASE 3

                                      1970      1971      1972

RDT AND E                               0.        0.        0.
INVESTMENT

  TRAINING AIRCRAFT                     0.        0.        0.
  SIMULATORS                            0.        0.        0.

  SPARES
     AIRCRAFT                           0.        0.        0.
     SIMULATOR                          0.        0.        0.

  AEROSPACE GROUND EQUIP.               0.        0.        0.
  TRAINING EQUIPMENT                    0.        0.        0.
  BASE SUPPORT EQUIPMENT                0.        0.        0.
  RUNWAYS                               0.        0.        0.
  STOCKS                                0.        0.        0.
  INITIAL TRAINING                      0.        0.        0.
  INITIAL TRAVEL                        0.        0.        0.

OPERATING

  RECURRING MODIFICATIONS               0.        0.        0.

  TRAINING A/C MAINTENANCE
     DEPOT MAINTENANCE               1552.     1552.     1552.
     BASE MATERIAL                   2116.     2116.     2116.
     CONTRACTED MAINTENANCE             0.        0.        0.

  TRAINING A/C POL                   2163.     2163.     2163.
  SIMULATOR MAT. AND SERVS.            15.       15.       15.
  FACILITIES MAT. AND SERVS.          354.      354.      354.
  CONTRACTED FLYING TRAINING            0.        0.        0.

  PAY AND ALLOWANCES
     OFFICERS                        4046.     4046.     4046.
     AIRMEN                          3517.     3517.     3517.
     CIVILIANS                       1354.     1354.     1354.

  TRAINING                            400.      400.      400.
  TRAVEL                               67.       67.       67.
  SUPPLIES AND SERVICES               443.      443.      443.

COST BY TYPE

  RDT AND E                             0.        0.        0.
  INVESTMENT                            0.        0.        0.
  OPERATING                         16027.    16027.    16027.
  TOTAL                             16027.    16027.    16027.
```

Fig. 16—Twelfth page of output, showing UPT costs for training phase III

```
UNDERGRADUATE PILOT TRAINING COSTS (IN THOUSANDS OF DOLLARS)
                  NOT ASSIGNABLE TO PHASE

                                      1970       1971       1972
INVESTMENT

  SUPPORT AIRCRAFT                     0.         0.         0.
  RESCUE AND RECOVERY A/C              0.         0.         0.
  BASE SUPPORT EQUIPMENT               0.         0.         0.

  FACILITIES
     NEW BASE CONVERSION               0.         0.         0.
     SIMULATOR BUILDINGS               0.         0.         0.
     CLASSROOM BUILDINGS               0.         0.         0.
     FLY. TRAIN. BASIC BLDGS.          0.         0.         0.
     HOUSING                           0.         0.         0.
     OTHER                             0.         0.         0.

  STOCKS                               0.         0.         0.
  INITIAL TRAINING                     0.         0.         0.
  INITIAL TRAVEL                       0.         0.         0.

OPERATING

  SUPPORT A/C O AND M                  0.         0.         0.
  R AND R A/C O AND M                 74.        74.        74.
  FACILITIES MAT. AND SERVS.         786.       786.       786.

  PAY AND ALLOWANCES
     OFFICERS                       1503.      1503.      1503.
     AIRMEN                         3621.      3621.      3621.
     CIVILIANS                      2029.      2029.      2029.

  TRAINING                           407.       407.       407.
  TRAVEL                             578.       578.       578.
  SUPPLIES AND SERVICES              357.       357.       357.

COST BY TYPE

  INVESTMENT                           0.         0.          .
  OPERATING                         9356.      9356.       935.
  TOTAL                             9356.      9356.       935.
```

Fig. 17—Thirteenth page of output, showing UPT costs not allocated to training phases

```
              UNDERGRADUATE PILOT TRAINING COST SUMMARY
                      (IN THOUSANDS OF DOLLARS)

                                           1970       1971       1972

COST BY TYPE

  RDT AND E                                  0.         0.         0.
  INVESTMENT                                 0.         0.         0.
  OPERATING                              35472.     35472.     35472.
  TOTAL                                  35472.     35472.     35472.

COST BY PHASE

  PHASE 1                                 1315.      1315.      1315.
  PHASE 2                                 8773.      8773.      8773.
  PHASE 3                                16027.     16027.     16027.
  NOT ASSIGNABLE TO PHASE                 9356.      9356.      9356.
  TOTAL                                  35472.     35472.     35472.

COST BY BASE

  BASE  1                                35472.     35472.     35472.
  NOT ASSIGNABLE TO BASE                     0.         0.         0.
  TOTAL                                  35472.     35472.     35472.
```

Fig. 18—Fourteenth page of output, showing UPT costs in summary for all bases

Force at any given time. The purpose of this analysis is to determine the production-cost relationship that exists (as UPT is currently conducted) regardless of the availability of equipment and facilities. Investment costs, therefore, were excluded from these computations of per-graduate costs.

The relationship between the UPT production level and UPT per-graduate costs was determined by plotting the per-graduate cost obtained from the output of the model against the production from 3100 to 5200. The results are shown in Fig. 19. The cost per graduate declines relatively rapidly until the UPT system reaches its capacity, but when a new base is opened to provide the necessary additional capacity, the cost per graduate jumps, reflecting the immediate effect of the increase

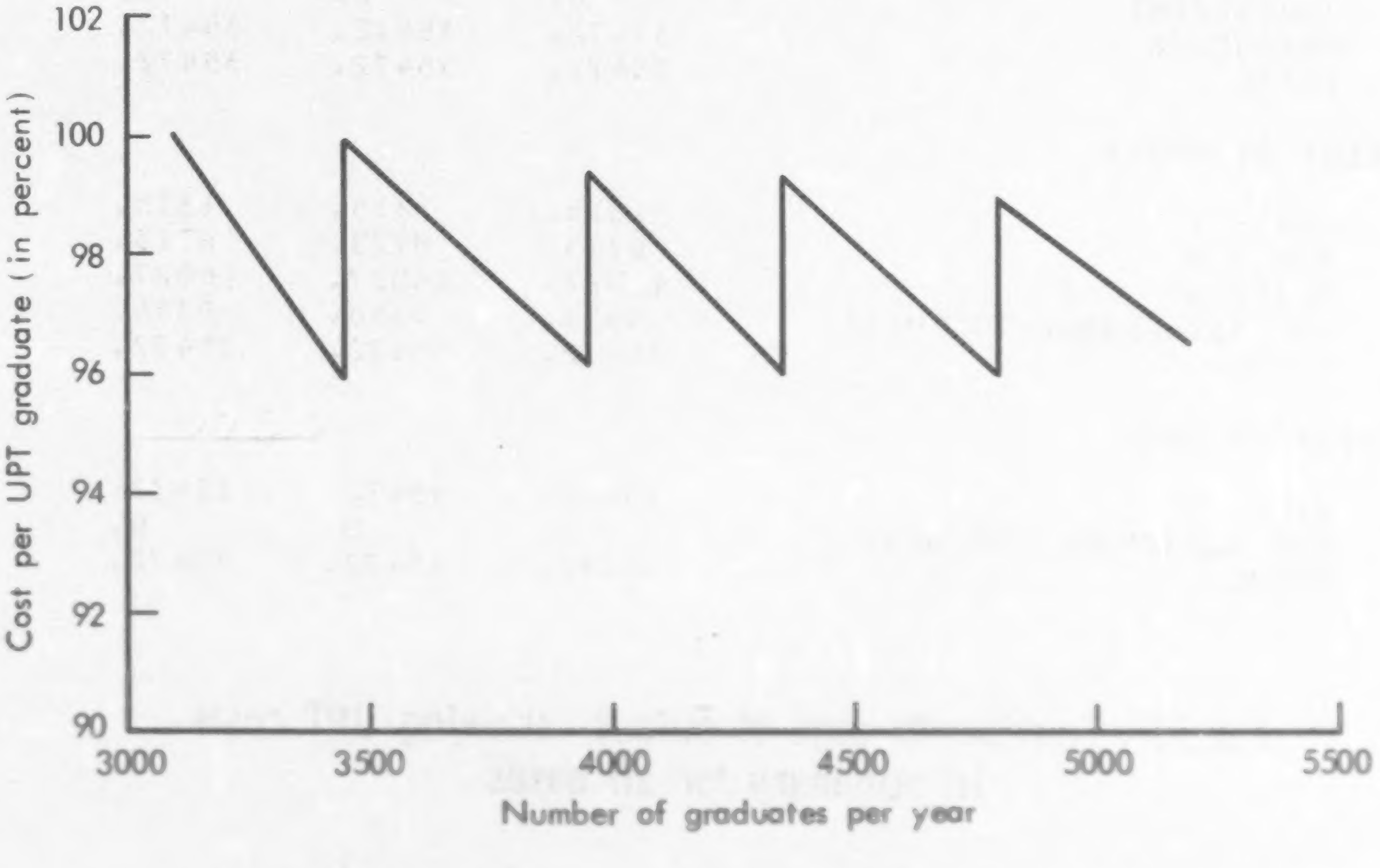


Fig. 19—Cost per UPT graduate (in percent) as a function of the number of graduates: Detailed pattern (3100 graduates = base of 100%)

in fixed operating costs occasioned by the new base. The saw-tooth pattern in Fig. 19 is not uniform because bases have different operating costs and capacities, and because the fixed costs are spread over different numbers of students.

The fluctuations shown in Fig. 19 should not obscure the fact that the cost per graduate declines only slightly as the number of graduates is increased. As shown in Fig. 20, an increase from 3100 to 5200 resulted in a decrease of less than three percent.

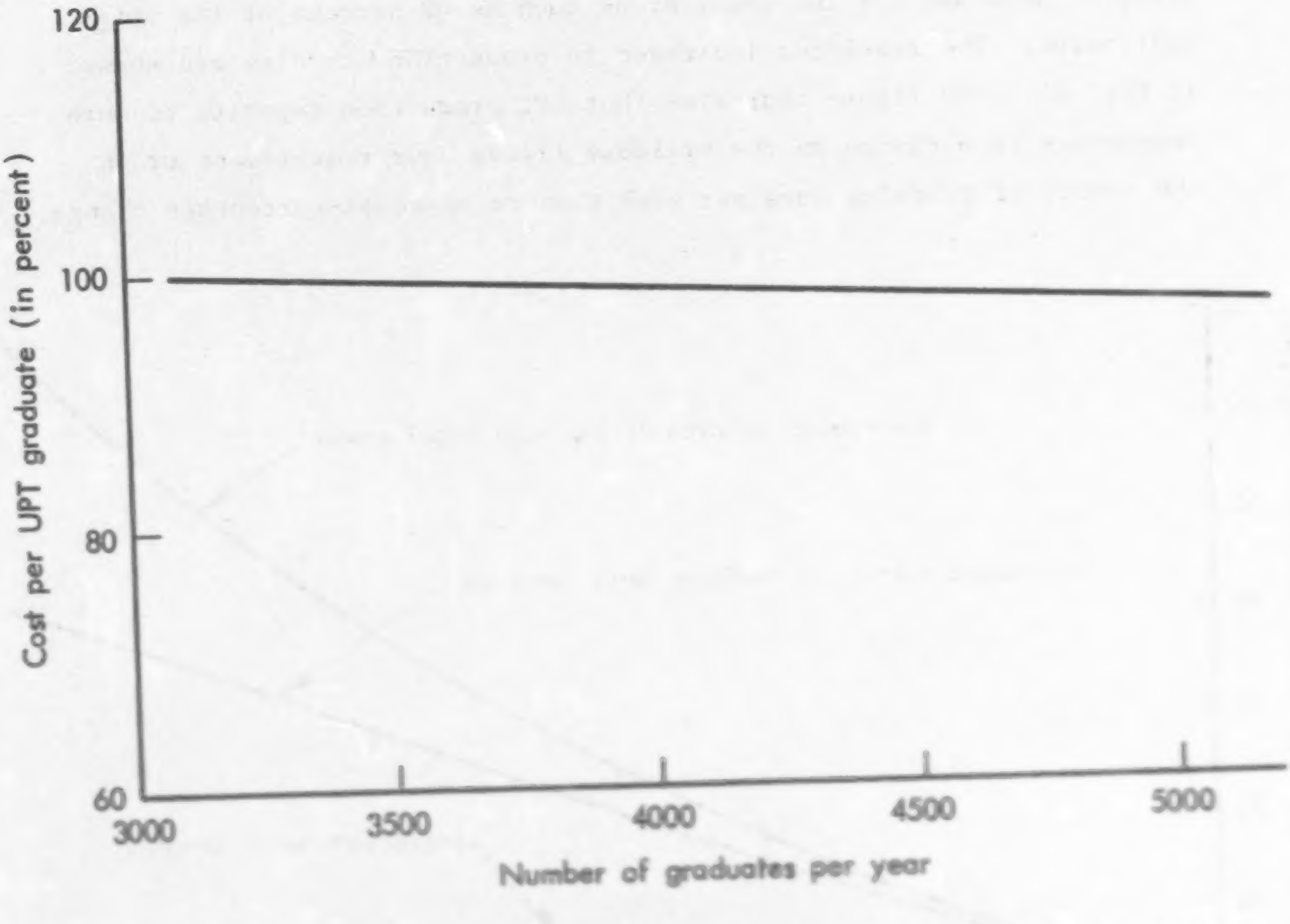


Fig. 20—Cost per UPT graduate (in percent) as a function of the number of graduates: General effect (3100 graduates = base of 100%)

Training Capacity

Adding a new base is not the only way to increase the capacity of UPT. Four other methods are as follows:

1. Decrease the syllabus flying hour requirement.
2. Increase the number of training days per week.
3. Increase the sortie length.
4. Decrease the number of aborted takeoffs.

The model was exercised repeatedly, allowing each of these four variables to decrease (or increase) by as much as 40 percent of its original value. The resulting increases in production capacity are shown in Fig. 21. The figure indicates that UPT production capacity is more responsive to a change in the syllabus flying hour requirement or in the number of training days per week than to an equal-percentage change

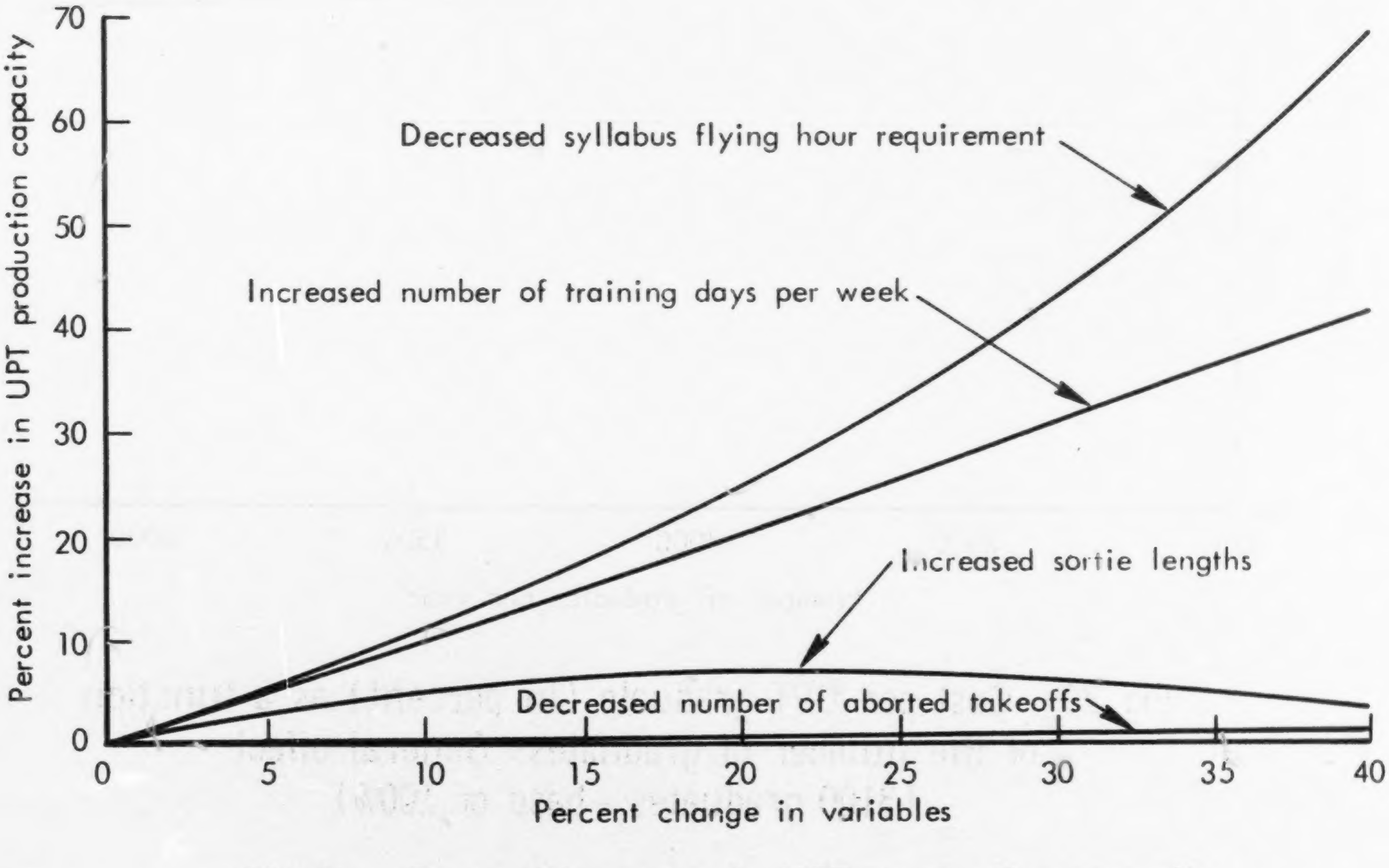


Fig. 21—Percent increase in UPT production capacity as a function of changes in several variables

in the sortie length or in the number of aborted takeoffs. Training capacity increases at an accelerated rate as the syllabus flying hour requirement decreases. As the decrease in the flying hour requirement approaches 100 percent, capacity approaches infinity.

Capacity increases proportionately with an increase in working days per week. The 40 percent increase shown in Fig. 21 represents a change from a 5-day week to a 7-day week.

As the sortie length is increased from its present length, capacity first increases, then decreases. When the sortie length is increased, fewer sorties are flown. Therefore, each student requires fewer launch intervals. However, the time available for takeoffs is the number of daylight hours less one sortie length at the end of the day. This determines the latest time that the last flight of the day may be launched if it is to return for a daylight landing. Thus, there is a point beyond which sortie lengths cannot be increased without loss of daylight hours and, consequently, decrease in training capacity.

Capacity varies linearly with a decrease in the number of aborted takeoffs. Capacity is relatively insensitive to a change in aborted takeoffs because the percentage of takeoffs that are aborted is relatively small.

Figure 21 shows the effects of changes only in variables on UPT production capacity. Other consequences, such as the effect on cost and and possibly on the quality of pilots produced, are not considered.

V. DETAILED DESCRIPTION OF THE UPT MODEL

In this section, the UPT model is discussed in detail. Calculations are discussed in the order in which they are made in the model, and simplified flow diagrams are presented. The complete flowcharts (including all equations) from which the UPT computer program was written are presented in Volume V of the study.*

The UPT model has seven parts, or segments, as follows:

Segment
1. Course length
2. Student load
3. Training capacity
4. Manpower
5. Equipment
6. Facilities
7. Cost

Each segment consists of the inputs and calculations of one step in estimating the resources and costs of UPT. An extremely simplified flow diagram of the model is shown in Fig. 22. The seven segments are processed in the order listed above. Upon the completion of Segments 3 through 7, output is printed describing the results to those points.

The output that follows Segment 6 is a "dump," rather than an output table like those shown in Section IV. A dump contains a list of the values of all variables calculated in a particular segment of the model. If the user of the model desires, he may also have dumps printed immediately ahead of the output tables following Segments 3, 4, 5, and 7. A dump can aid the user in determining how numbers found in the output tables were derived.

SEGMENT 1: COURSE LENGTH

In Segment 1, the length of each training phase is calculated and then summed to obtain the length of the entire UPT course. A simplified flow diagram of this process is depicted in Fig. 23.

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*See Preface.

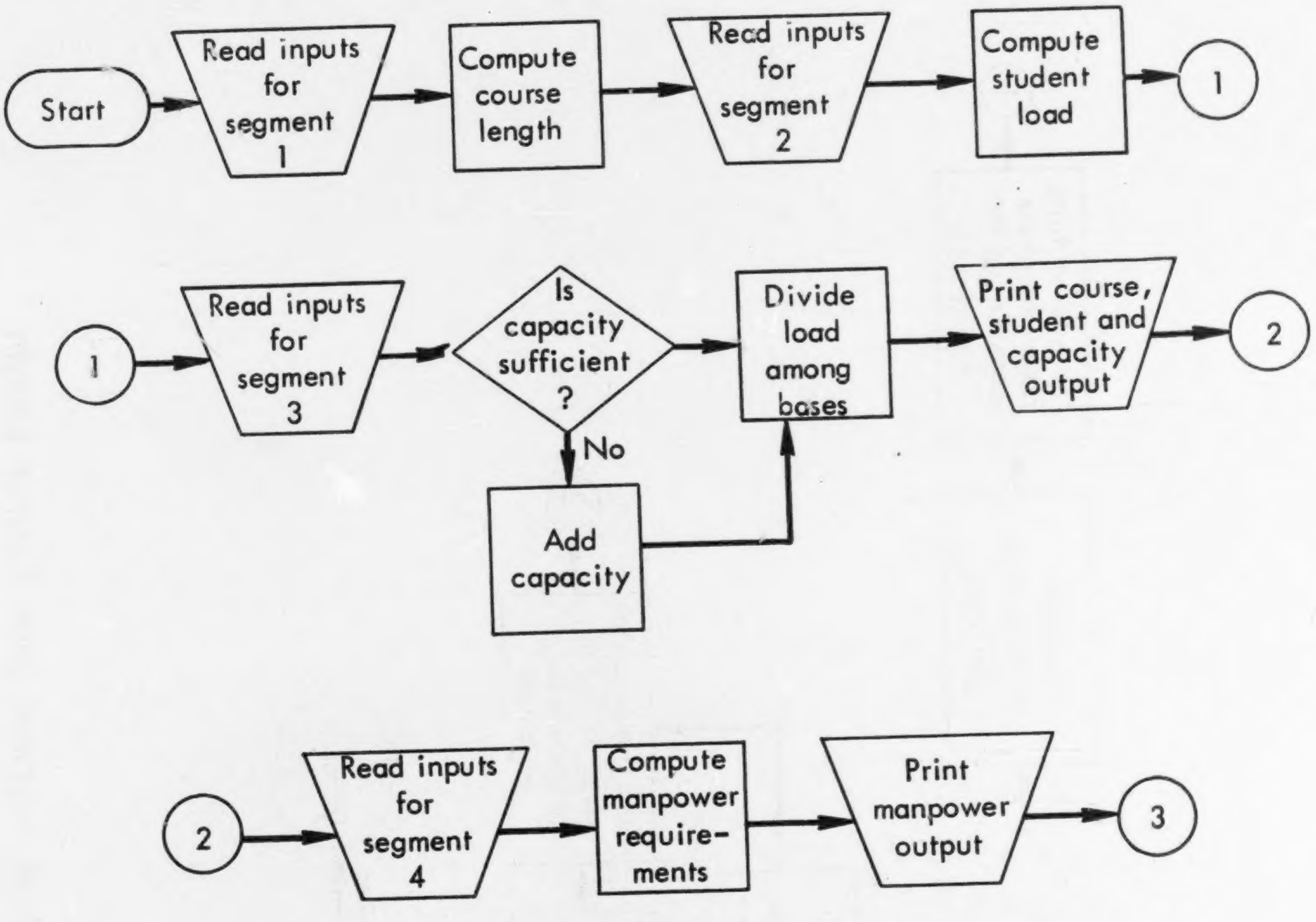
Start
Read inputs for segment 1
Compute course length
Read inputs for segment 2
Compute student load
1
1
Read inputs for segment 3
Is capacity sufficient ?
No
Add capacity
Divide load among bases
Print course, student and capacity output
2
2
Read inputs for segment 4
Compute manpower require-ments
Print manpower output
3
3
Read inputs for segment 5
Compute equipment require-ments
Print equipment output
4
4
Read inputs for segment 6
Compute facility require-ments
Print facility output
5
5
Read inputs for segment 7
Compute costs
Print cost output
Stop

Fig. 22— Simplified flow diagram of the UPT model

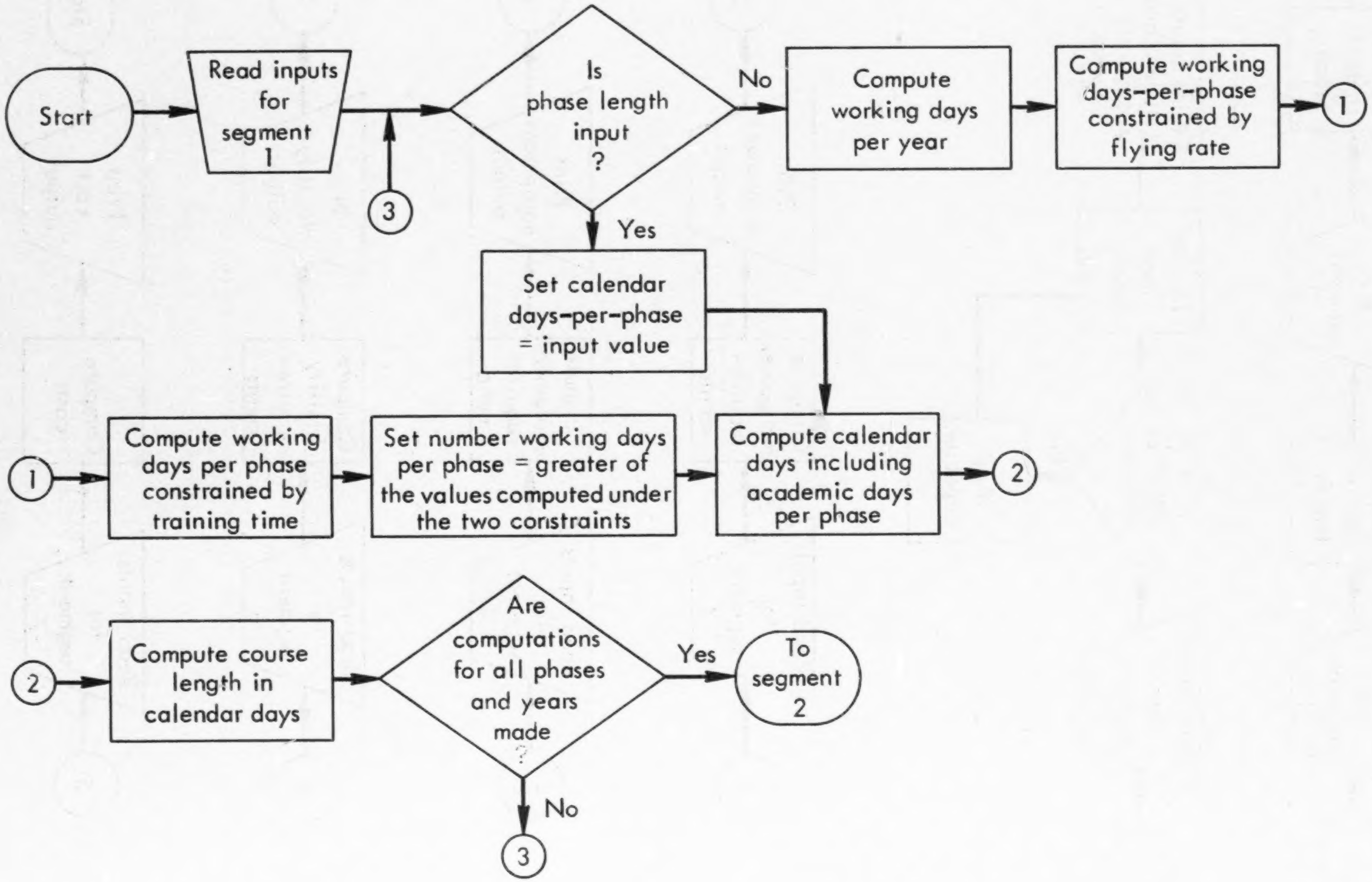
Start
Read inputs for segment 1
3
Is phase length input ?
No
Yes
Compute working days per year
Compute working days-per-phase constrained by flying rate
1
Set calendar days-per-phase = input value
1
Compute working days per phase constrained by training time
Set number working days per phase = greater of the values computed under the two constraints
Compute calendar days including academic days per phase
2
2
Compute course length in calendar days
Are computations for all phases and years made ?
Yes
To segment 2
No
3

Fig. 23—Simplified flow diagram of Segment One: Course Length

The model computes the length of each phase as the sum of two periods of time, arbitrarily designated as the ground training period and the flight training period. The ground training period is defined as one in which no flight training is given, i.e., it may consist of any combination of ground training activities (e.g., orientation sessions, classroom instruction, simulator training, drill and physical training). It includes no airborne training and, hence, may be scheduled without regard to weather. (Currently, ground training, as defined here, is given only during the first week of Phase I training.) The second of the two time periods, designated as flight training, commences on the day that flight training starts and continues to the end of the phase. This feature was incorporated in the model for two reasons: One, because the first week of Phase I instruction, as it is currently given, does not include any flight training. Two, because there is a possibility, however remote, that the user of the model may wish to provide a longer period of Phase I ground training or he may wish to provide a period consisting exclusively of ground training in the other phases.

The length of the ground training period (in training days) for each phase is specified by the user.

The number of flying training days in the phase may be determined in either of two ways. For each year, the user has the option of (a) specifying the number of calendar days in each phase, or (b) allowing the model, first, to compute the number of working days in each phase and, then, to convert this to the number of calendar days.

If the phase length is computed by the model, it is computed as the greater of (a) the phase length constrained by the average number of flying hours a student can fly per day* and the syllabus flying-hour requirement, and (b) the phase length constrained by the total time allotted each day for all aspects of training, including time spent in such activities as flight briefings and debriefings. Next, the number of flying-training working days (if the number of flying-training working days were computed by the model) and the number of ground training working days are converted to calendar days on the basis of the number of working days per year. The number of working days per year is calculated from inputs for the number of working days per week and the number of holidays per year. The numbers of academic training and flying training calendar days are summed, yielding the total number of calendar days in the phase.

---

*The maximum rate at which he can effectively absorb flying training.

To illustrate the calculation of the phase length: If the flying hour requirement of the phase were 95 hours and the maximum flying training hours per working day per student were 0.95, the number of flying training working days constrained by flying would be 100 days (95/0.95 = 100). If the total number of training hours were 720 and the working hours per day were 8, then the working days per phase constrained by the working hours per day would be 90 days (720/8 = 90). The longer of the two training times, 100 days, would be the number of flying training working days required for that phase. If there were 250 working days in the year, 146 flying training calendar days would be required (100 x [365/250] = 146). Assuming that 15 ground training working days are specified, 22 ground training calendar days would be required (15 x [365/250] = 22). The total phase length would be 168 calendar days. After the length of each phase has been determined, the days per phase are summed to obtain the course length. The course 1 length is determined for each year before proceeding to the next segment.

SEGMENT 2: STUDENT LOAD

Figure 24 shows a simplified flow diagram of Segment 2. In this segment, the average number of students undergoing training during a given year (the student load) is computed. The computation of student load is very important, because most of the resources and costs of UPT are a function of the number of students being trained.

An implicit assumption of the model is that students enter and graduate in a smooth flow over time, rather than entering and graduating in classes. Figure 25 illustrates the assumed flow of 4000 students

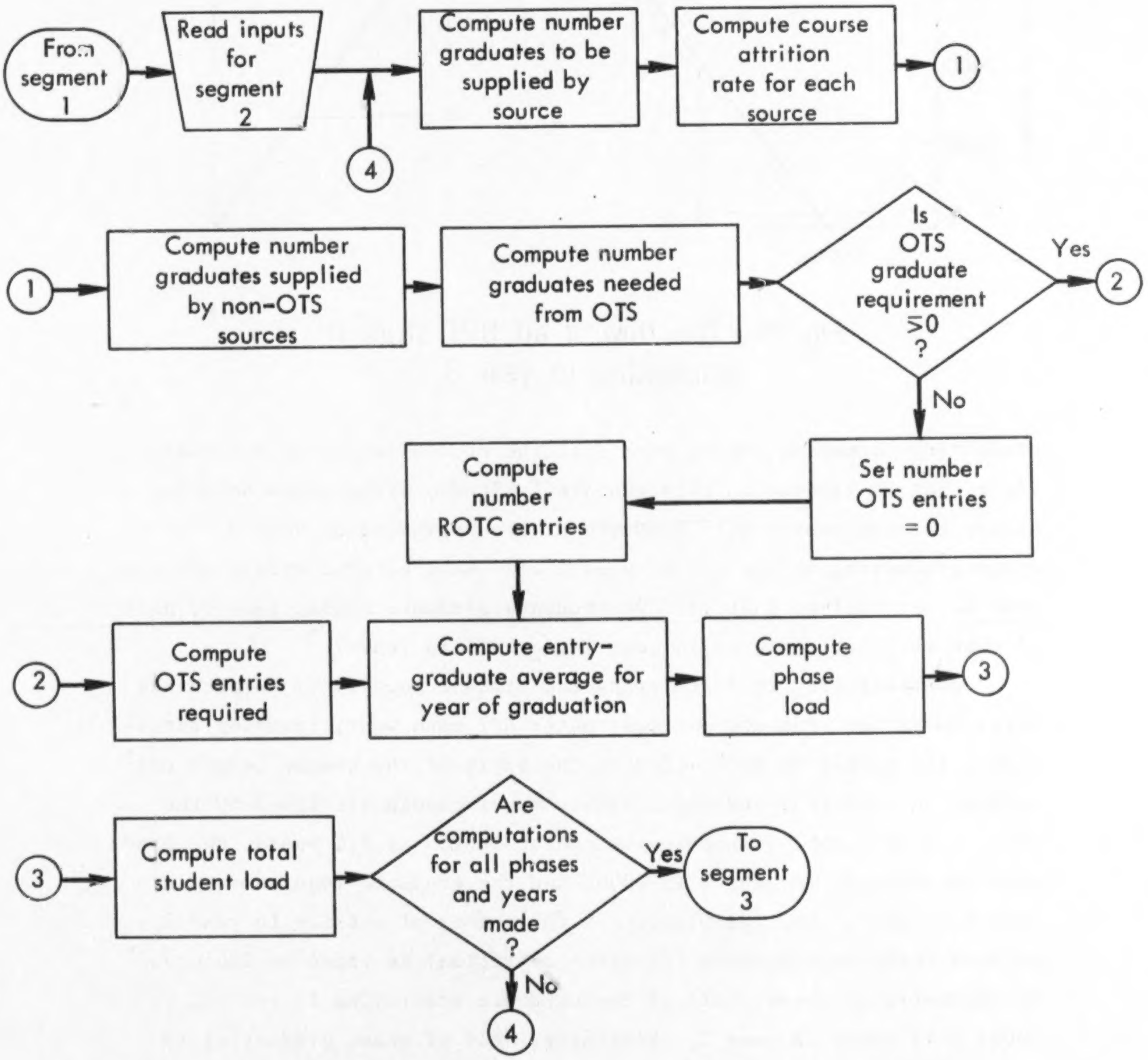
From segment 1
Read inputs for segment 2
Compute number graduates to be supplied by source
Compute course attrition rate for each source
1
4
1
Compute number graduates supplied by non-OTS sources
Compute number graduates needed from OTS
Is OTS graduate requirement ≥ 0 ?
Yes
2
No
Set number OTS entries = 0
Compute number ROTC entries
2
Compute OTS entries required
Compute entry-graduate average for year of graduation
Compute phase load
3
3
Compute total student load
Are computations for all phases and years made ?
Yes
To segment 3
No
4

Fig. 24—Simplified flow diagram of Segment Two: Student Load

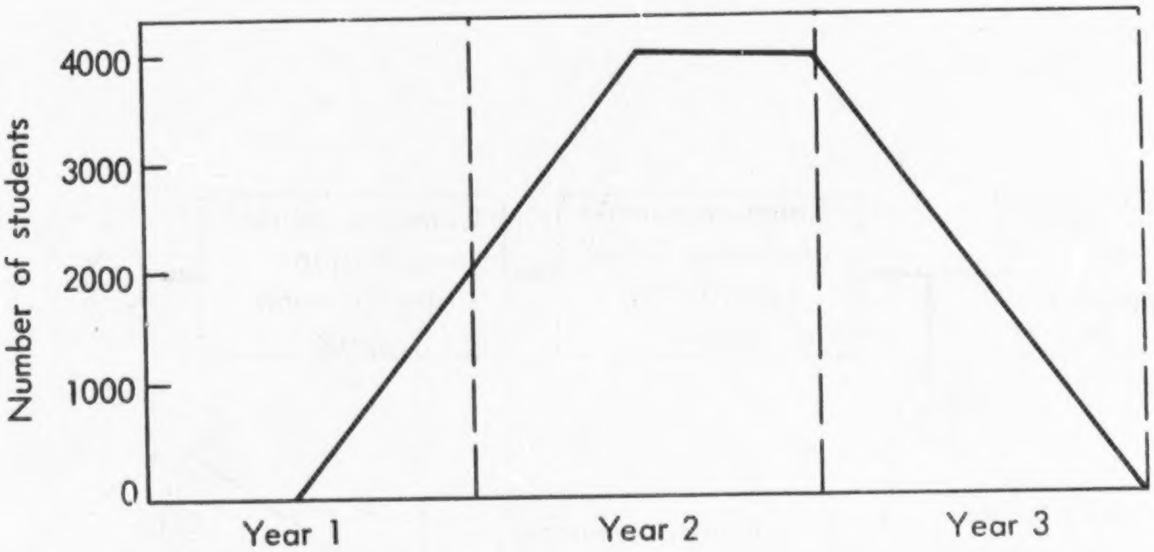

Fig. 25—The flow of all UPT students graduating in year 3

graduating sometime during year 3 if the course length is 1.5 years. (Attrition is ignored in this example.) Students who begin entering midway through year 1 will graduate at the beginning of year 3. Students graduating at the end of year 3 will have entered midway through year 2. It follows that if 4000 students graduate during year 3, half of them must have entered in year 1 and half in year 2.*

The first step in calculating the student load is to compute the total number of students who must enter UPT each year, ignoring attrition. The number is determined on the basis of the course length calculated in Segment 1 and the graduate requirements specified by the user. As an example, suppose the course length is 1.5 years, the graduate requirement in year 3 is 4000, and the graduate requirement in year 4 is 3000. The calculation of the number of entries in year 2 to meet these requirements (ignoring attrition) is shown in Table 7. As demonstrated above, half of the students graduating in year 3, or 2000, will enter in year 2. Similarly, half of those graduating in year 4, or 1500, will enter in year 2. Thus, the total number of students entering in year 2 will be 3500.

---

*In actual practice, students enter in groups and the groups vary somewhat in size.

Table 7

CALCULATION OF NUMBER OF STUDENTS ENTERING
IN YEAR 2 (EXCLUDING ATTRITION) TO MEET
REQUIREMENTS FOR GRADUATES

	Year 1	Year 2	Year 3	Year 4
Course length (years)			1.5	1.5
Graduate requirement			4000	3000
Entering students graduating in year 3	2000	2000	---	---
Entering students graduating in year 4	---	1500	1500	---
Total year 2 entries, excluding attrition		3500		

Next, the required number of OTS entries is calculated, with allowance being made for attrition. The number of entries from each of the non-OTS sources (Academy, ROTC, rated on active duty, non-rated on active duty, and other)* is specified by the user. The number of graduates to be obtained from these non-OTS entries is computed on the basis of the course attrition rates. The computed number of graduates from these sources is then subtracted from the total number of graduates required, to obtain the graduate requirement to be filled from OTS. This method of computing the OTS entry requirement is the same as shown in Table 4.

To continue the Table 7 example, assume that 2500 persons will enter UPT in year 2 from non-OTS sources, and that their attrition rates are all 20 percent. Then, 2000 of the non-OTS entrants in year 2 will graduate. The additional 1500 graduates must come from OTS entrants. Assuming the OTS attrition rate is 30 percent, 2143 OTS entries will be needed in year 2 (1500/.70 = 2143).

It is theoretically possible that the number of graduates required from OTS as computed by the model will be less than zero. If this happens, the number of entries from ROTC is reduced, and the OTS entry requirement is set to zero. If ROTC entries are reduced to zero and the OTS requirement remains negative, an error message results, and no further calculations are made.

---

*See Sources of Students, p. 8.

Next, for students who graduate within the same year, a simple average is taken of the number of students entering a phase and the number graduating from the phase based on the student attrition rates for each phase. This is the "entry-graduate" average. For example, if 4500 students must enter Phase III in order to graduate 4000 in year 3, the Phase III entry-graduate average for year 3 graduates is 4100.

In effect, the model assumes that half of the attrition within a given phase occurs at the beginning of the first day and half at the end of the last day. Thus, it is assumed that 4100 students will be undergoing Phase III training throughout the entire phase. In reality, 4200 students would begin Phase III; then, the number of students would diminish day by day until on the last day only 4000 remained. Because attrition is assumed to occur at only the beginning and end of a phase, the calculations of the model are greatly simplified. Attrition computed in this manner results in only a 1 to 2 percent difference in student load from that obtained by computing attrition as it actually occurs.

Next, the student loads resulting from UPT graduate requirements for a given year are calculated. To illustrate the calculation of the Phase III load resulting from students graduating in year 3, assume that the Phase III entry-graduate average for year 3 graduates is 4100 and the length of Phase III is 0.5 year. Figure 26 illustrates the assumed flow within Phase III of students graduating in year 3. The load varies from 0 to midyear to 2050 at the end of the year, because half of the Phase III entry-graduate average is assumed to enter in Year 2 and half in year 3. The average Phase III, year 2 load for graduates of year 3 is 512 student years (1/2 x 1/2 x 2050), represented by the area under the curve in year 2.

The 4000 graduates of year 3 create student loads in Phases I and II also. If the course were 1.5 years in length, the Phase I load for graduates of year 3 would extend backwards into year 1.

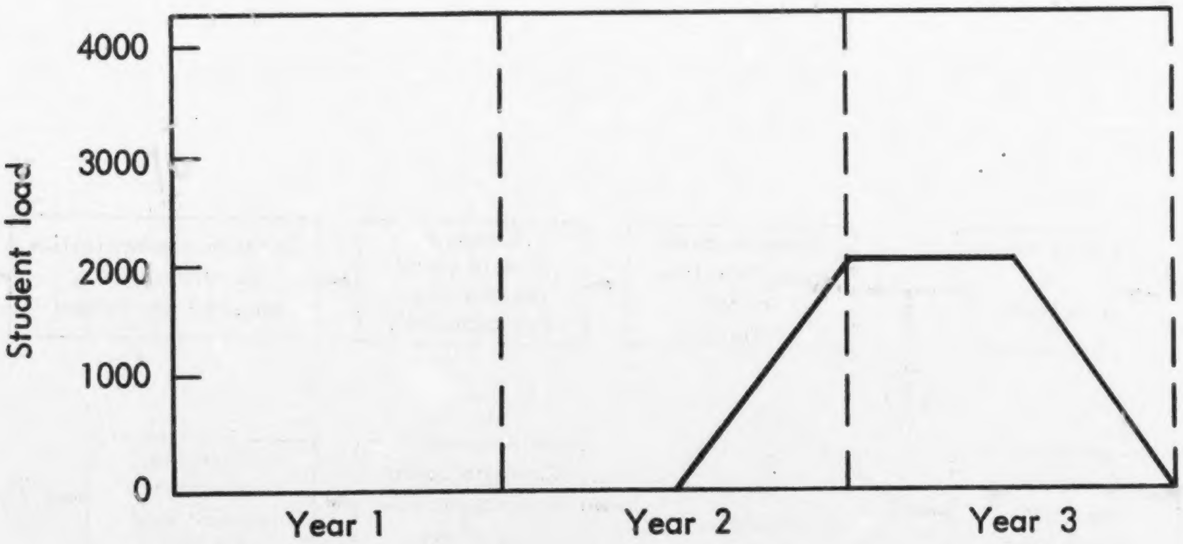

Fig. 26—The flow of Phase-III students graduating in year 3

To determine the total student load for each phase and year, the model computes the loads due to graduates of year 1, year 2, year 3, and so on, until the last year of the model. In this manner, the model calculates the student load within each phase and year due to students graduating each year. Then, the student loads within each year are s summed for each phase. To illustrate, consider the example of Fig. 26. A Phase III student load of 512 was created in year 2 due to year 3 graduates. An additional amount of Phase III load would be created in year 2 due to year 2 graduates. The model sums these two amounts to obtain the total Phase III student load in year 2.

Finally, the total UPT student load for each year is calculated by summing the student loads of all the phases.

SEGMENT 3: TRAINING CAPACITY

In Segment 3, the training capacity of the UPT system, in terms of maximum student load, is calculated. It is compared with the required student load calculated in Segment 2, and additional capacity is added if needed. When sufficient capacity is obtained, the total student load is apportioned to the UPT bases. A simplified flow diagram of Segment 3 appears in Fig. 27.

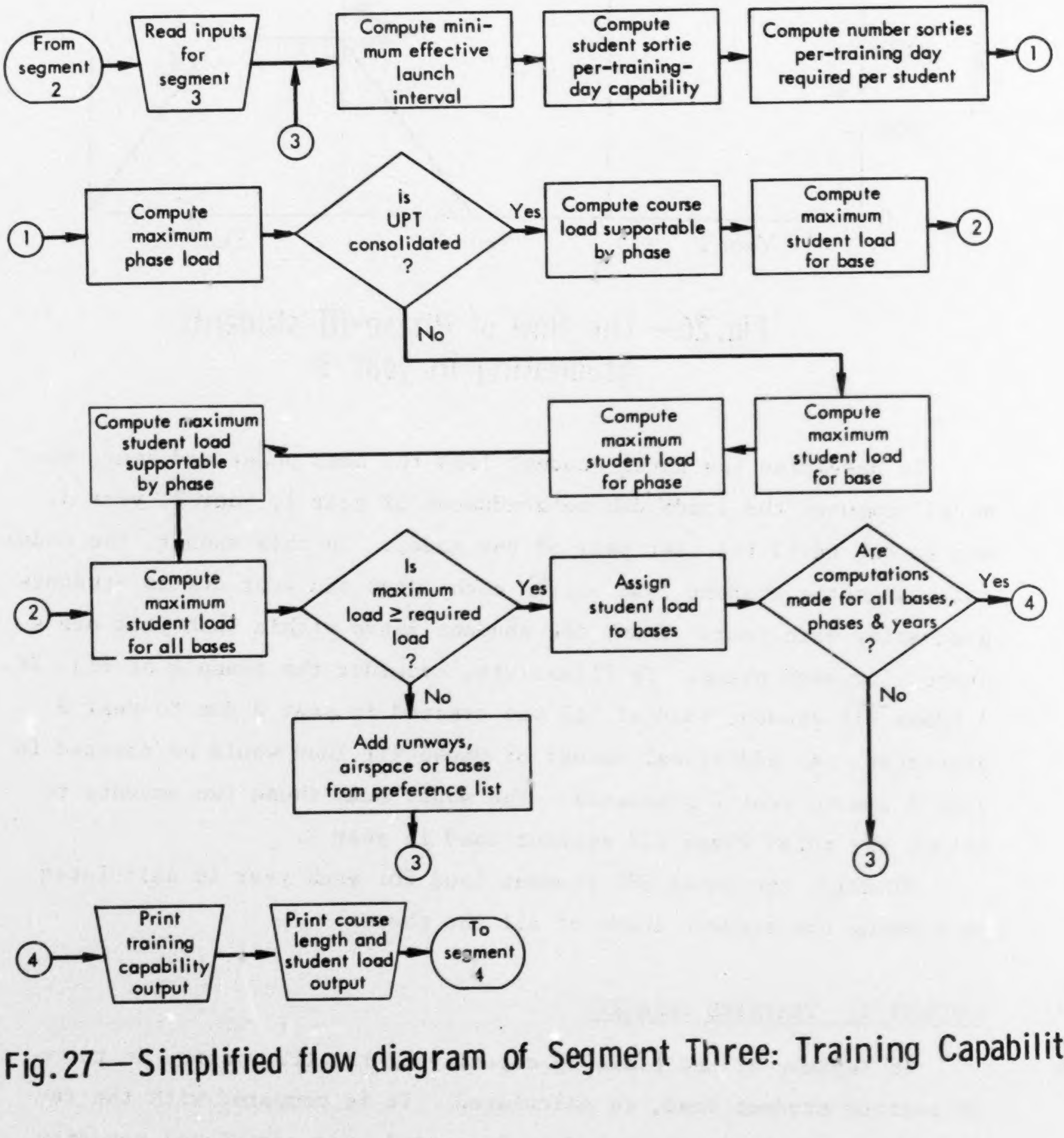
From segment 2
Read inputs for segment 3
Compute minimum effective launch interval
Compute student sortie per-training-day capability
Compute number sorties per-training day required per student
1
3
1
Compute maximum phase load
Is UPT consolidated ?
Yes
No
Compute course load supportable by phase
Compute maximum student load for base
2
Compute maximum student load supportable by phase
Compute maximum student load for phase
Compute maximum student load for base
2
Compute maximum student load for all bases
Is maximum load ≥ required load ?
Yes
No
Assign student load to bases
Are computations made for all bases, phases & years ?
Yes
No
4
Add runways, airspace or bases from preference list
3
3
4
Print training capability output
Print course length and student load output
To segment 4

Fig. 27—Simplified flow diagram of Segment Three: Training Capability

First, the capacity of a phase on a given base is calculated. As an example, the capacity of Phase II on UPT Base 1 represents the maximum number of Phase II students that facilities for Phase II training on Base 1 can accommodate. The training capacity of a given phase and UPT base is assumed to be subject to two constraints: the number of runways and the amount of airspace. It is assumed that any other resources, such as instructor pilots, aircraft, simulators, and classrooms, are automatically supplied as needed and that the appropriate costs are charged.*

The two constraints are compared as they affect the minimum obtainable launch interval--the interval that must be maintained between successive takeoffs. The launch interval constrained by runways is the minimum interval that the base's air traffic control system can maintain on each runway. It is multiplied by the number of runways used for the phase to obtain the effective launch interval constrained by runways. The effective launch interval constrained by airspace is a function of the maximum number of aircraft the base's allotted airspace can accommodate. It is calculated by dividing the number of flying areas available by the average sortie length. The greater of the two launch intervals thus calculated is equated to the minimum obtainable launch interval for the given phase and base.

Next, the daily student sortie capability, i.e., the maximum number of student sorties that can be flown during any day, is computed from the effective launch interval and from inputs specifying the number of daylight hours per day, the percentage of sorties flown by other than students, the percentage of days with weather suitable for flying, and the percentage of sorties not flown because the preflight checkout was not satisfactorily completed. The sortie-per-training-day requirement per student, i.e., the number of sorties required to be flown by a student each training day, is calculated from the flying-hour-per-training-day requirement computed in Segment 1, the sortie length, and the percentage of student sorties that are flown during daylight hours.

The maximum student load for the phase and base is calculated by dividing the student sortie-per-day capability by the sortie-per-day requirement per student and multiplying the result by a factor that adjusts for the seasonal variation in flyable weather. For example, if the daily student sortie capability for Phase II on Base 1 were 375 sorties per day, the sortie-per-training-day requirement were 1 sortie per student and the seasonal variation factor were .80, the maximum Phase II load on Base 1 would be 300 students ([375/1] x .80 = 300).

---

*See p. 25, Automatic Response Feature.

At this point, the model checks an indicator value specified by the user to determine whether the UPT course is "consolidated." The course is referred to as consolidated if all phases are taught at each UPT base and students remain at the base throughout the entire course, as is currently done. It is not consolidated if some portion of the course is not taught at each base.*

The capacity of a consolidated UPT system is different from one that is not consolidated. If the course is consolidated the numbers of students in each phase on a given base must be in the same ratio as the number of students in each phase within the entire UPT course. Otherwise, students could not remain at a single base throughout the course. For example, if the total UPT student load for Phases I, II, and III were 1000, 2000, and 3000, respectively, the numbers of students on each base would have to be in the ratio of 1 to 2 to 3. If a given base has the capacity in each of Phases II and III for 300 students, no more than 200 Phase II students could be accommodated, because the ratio of Phase II load to Phase III load must be 2 to 3.

Thus, if the course is consolidated, the model calculates, for the given base, the course load that the given phase can support. The course load supportable is computed by dividing the capacity of the phase and base by the percentage of total UPT students in that phase. Using the previous illustration, if the Phase II capacity of a particular base is 300 and Phase II students comprise 33 percent of the total UPT load (2000/6000 = 33%), Phase II can support a total course load of 900 students (300/.33 = 900) on that base.

The course load supportable on a given base is calculated for each phase. Then the capacity of the base is determined by equating it to the smallest course load supportable by all the phases. In the example, Phase II can support a load of 900 and Phase III can support a load of 600 (300/.50 = 600). Therefore, assuming the Phase I capacity is unlimited because this phase is conducted off base by civilian contractors, the capacity of the UPT base would be 600 students. After the capacity is calculated for each training base, the capacity of the entire UPT system is computed by summing the capacities of all bases.

---

*Although the present UPT course is consolidated, a system that is not consolidated has often been suggested as an alternative.

If UPT is not consolidated, the capacity of each base is simply the sum of the individual phase capacities for that base. When UPT is not consolidated, the individual base capacities are not used in computing the total UPT capacity, but they are used in assigning students to each of the bases.

Next, the capacity of a given phase is calculated for the total of all of the UPT bases. This is done by summing the phase capacity of all bases for a given phase. For example, if the UPT system contained 10 bases and their Phase II capacity were 300 each, the total Phase II load would be 3000. The total load of each phase is calculated in the same manner. Then the total UPT student load supported by each phase is determined by dividing the capacity of the phase by the percentage of total students in that phase. Using the previous example, Phase II could support a total load of 9000 students (3000/.33 = 9000). If the Phase II capacity were 4000, Phase III could support a total load of 8000 (4000/.50 = 8000).

The total UPT capacity is determined by equating it to the smallest total load supported. In the example, the UPT capacity would be 8000 students.

By this point, the total UPT capacity has been calculated, either under a consolidated system or under one that is not consolidated. Next, the UPT capacity is compared with the required student load calculated in Segment 2. If the capacity is insufficient, it must be increased according to a preference list specified by the user. Three types of additions may be specified: runways, airspace, or entire bases. After each addition is made, training capacity is re-computed. If the preference list is exhausted before sufficient capacity is added, an appropriate error message is printed and no further calculations are made.

If sufficient capacity is obtained, the total student load is apportioned to the bases. First, the ratio of total student load to total capacity is calculated. Then, each base is assigned a student load equal to the calculated ratio times the base's capacity.

SEGMENT 4: MANPOWER

When Segment 3 is finished, the model begins its calculations of estimated resource requirements and costs. With a single exception, the estimating equations in the model take one of two functional forms:*

1. Linear with a positive intercept.
2. Linear with a zero intercept.

In the remainder of this section, the value of the resource or cost being estimated by the first form is referred to as a "fixed quantity" or "fixed number" plus a "factor times" or "percent of" the independent variable, i.e., the variable upon which the estimate is based. Use of the second form is referred to as a "percent of," a "factor times," or a "cost per" the independent variable. In all cases, the values of the parameters, whether "fixed quantities," "factors," "percents," or "cost factors," are specified by the user as inputs rather than being built into the model.

In Segment 4, the number of persons either directly related to the UPT mission or supporting it are calculated. Figure 28 shows a simplified flow diagram of this segment. Manpower requirements are calculated separately for each UPT base, for each phase, and for each organizational unit. Requirements for each organizational unit are computed in this order:

- Operations
  - Pilot training squadron(s)
  - Student squadron
  - Simulator branch
- Maintenance
  - Field maintenance squadron
  - Organizational maintenance squadron

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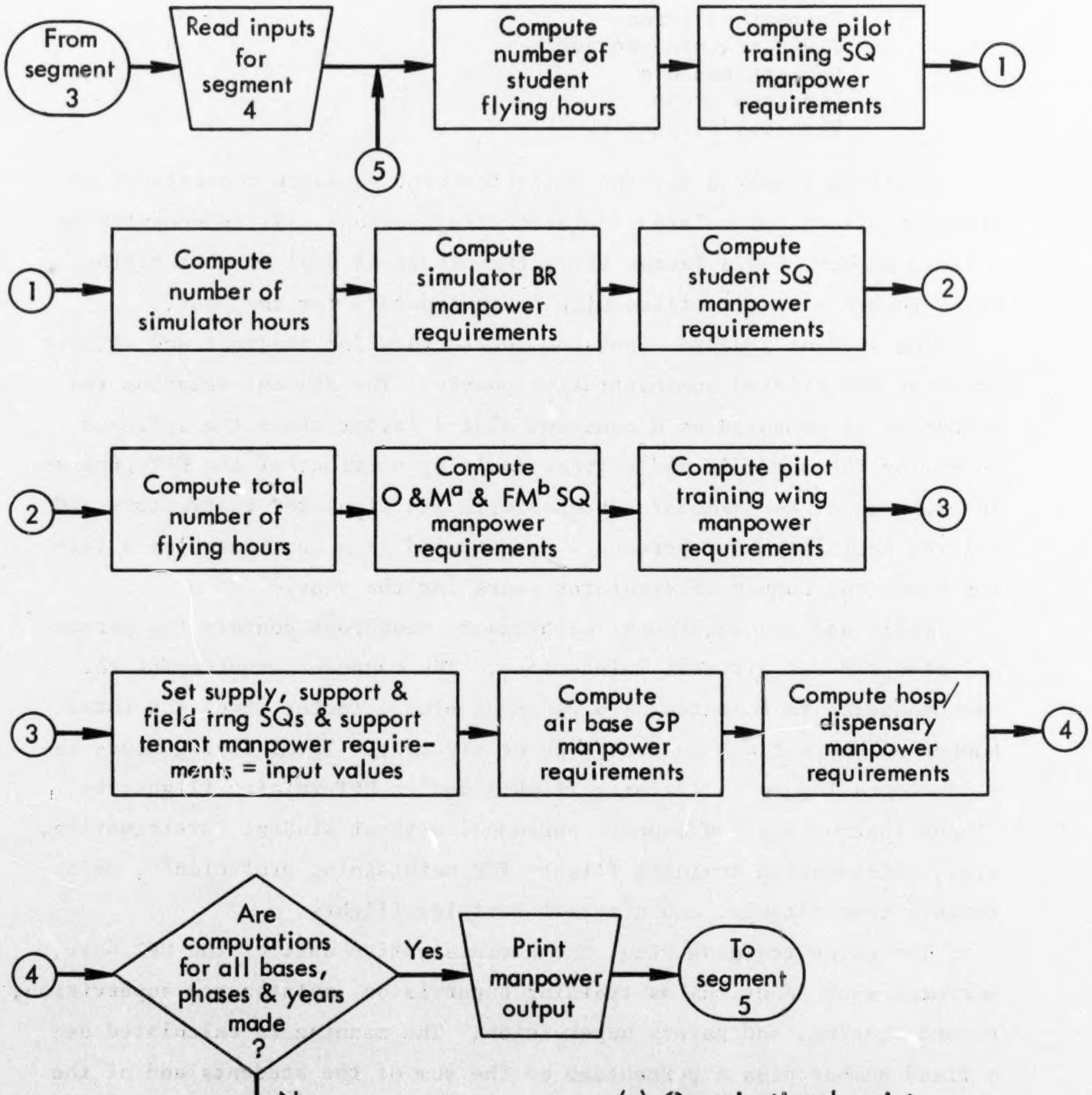
*The single exception is the equation for estimating the procurement cost of training aircraft, discussed in Segment 7.


From segment 3
Read inputs for segment 4
Compute number of student flying hours
Compute pilot training SQ manpower requirements
1
5
1
Compute number of simulator hours
Compute simulator BR manpower requirements
Compute student SQ manpower requirements
2
2
Compute total number of flying hours
Compute O & M^a & FM^b SQ manpower requirements
Compute pilot training wing manpower requirements
3
3
Set supply, support & field trng SQs & support tenant manpower requirements = input values
Compute air base GP manpower requirements
Compute hosp/ dispensary manpower requirements
4
4
Are computations for all bases, phases & years made ?
Yes
No
Print manpower output
To segment 5
5

(a) Organizational maintenance
(b) Field maintenance

Fig. 28—Simplified flow diagram of Segment Four: Manpower

Administrative
  Pilot training wing

Support
  Supply squadron
  Support squadron
  Field training squadron
  Support tenants
  Air base group
  Hospital/dispensary

Staffing required for the pilot training squadron consists of instructor pilots and related administrative persons. It is computed as a fixed number plus a factor times the number of dual student flying hours (hours a student flies with an instructor) for the year.

The student squadron contains instructors for academic and officer training and related administrative people. The student squadron requirement is computed as a constant plus a factor times the syllabus hours for the academic and officer training portions of the UPT program. The manning of the simulator branch with its simulator instructors and related administrative personnel is computed as a constant plus a factor times the number of simulator hours for the year.*

Field and organizational maintenance squadrons contain the personnel required for aircraft maintenance. The manpower requirement for each squadron is computed as a constant plus a factor times the total number of hours flown on each type of aircraft. Total flying hours include hours logged in training flights and in UPT-related flights by flight instructors and support personnel without student participation, e.g., continuation training flights for maintaining proficiency, maintenance test flights, and aircraft ferrying flights.

The pilot training wing, the administrative unit of the UPT base, performs such functions as training supervision, maintenance supervision, record keeping, and safety supervision. The manning is calculated as a fixed number plus a percentage of the sum of the students and of the military personnel in the instructor and maintenance organizations described above.

---

*Simulator instructors also perform maintenance on the simulators.

The remainder of the UPT manpower requirement is support personnel. The manpower requirements for the supply squadron, support squadron, field training squadron, and tenants supporting the UPT mission are specified by the user. Supporting tenants include organizations that would not be needed if the UPT base were closed, such as the communications squadron and weather squadron. The air base group manpower requirement is calculated as a fixed number plus a percentage of the sum of the student load and of the operations, maintenance, and administrative personnel. Air base group personnel perform such functions as base procurement, vehicle operation, mail and records, comptroller, personnel, civil engineer, and commissary. The USAF hospital (or dispensary) requirement is calculated as a fixed number plus a percentage of both the student load and all the military manpower requirements including the air base group.

After the number of people in each organizational unit has been calculated, the totals are divided among officers, airmen, and civilians based on percentages supplied by the user of the model. The military manpower requirements calculated thus far represent authorized numbers. The model converts the authorized military manpower requirements to assigned numbers, based on assignment factors. The manpower costs computed in Segment 7 are calculated from assigned military strength. If it is desired to base cost estimates on authorized strength, the user simply specifies assignment factors equal to 1, which equates assigned strength to authorized strength.

SEGMENT 5: EQUIPMENT

Figure 29 depicts the flow, in Segment 5, of the calculations of the number of training aircraft and simulators required.*

The aircraft requirement is estimated from the flying hours calculated in Segment 4 and from the aircraft utilization rates specified by the user. The available inventory of aircraft is determined by a net adjustment of the previous year's inventory, i.e., the subtraction

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*All other equipment, e.g., student training aids, motor vehicles, and aircraft test equipment, is considered only in dollar terms and is therefore treated in Segment 7, where costs are estimated.

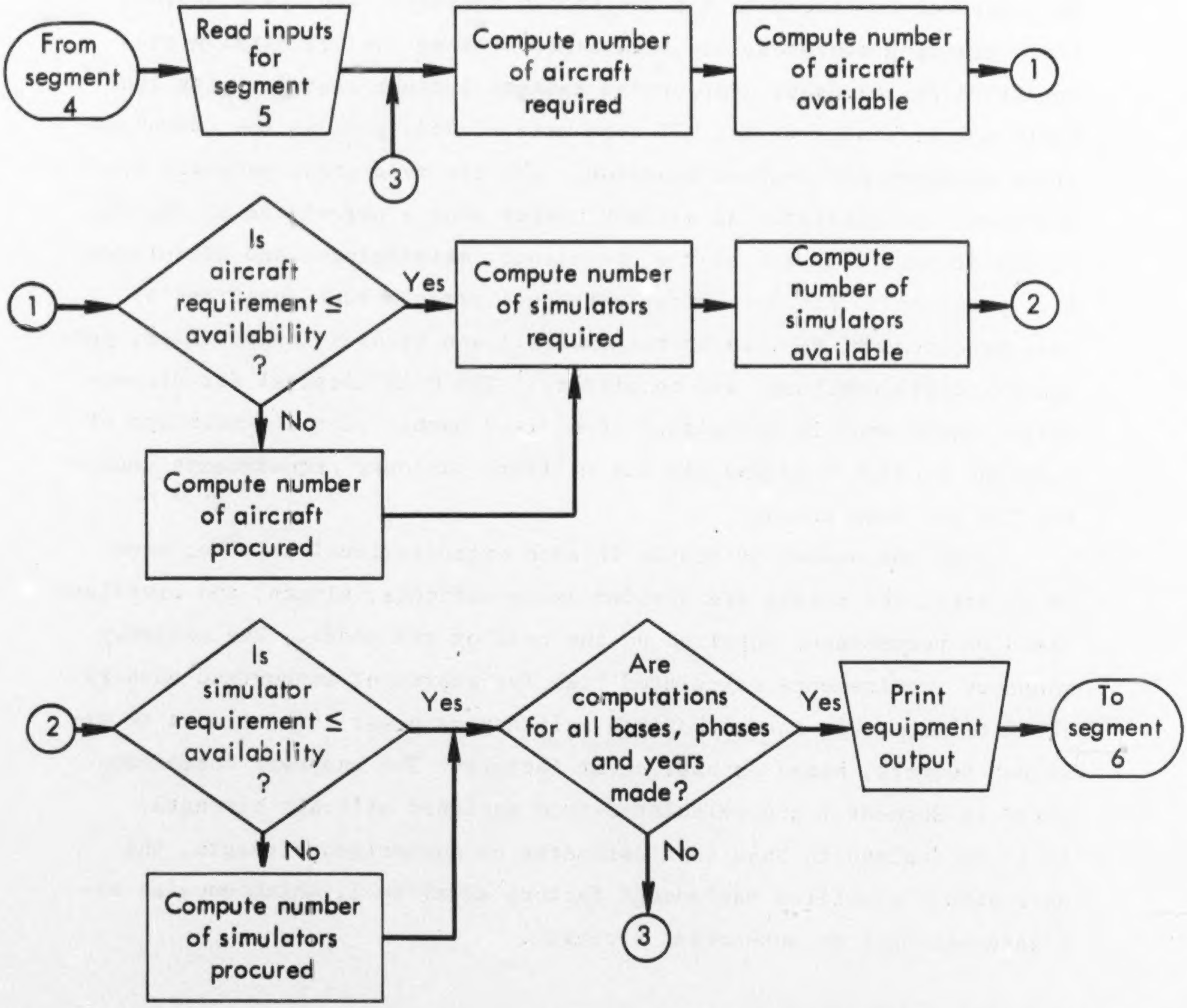
From segment 4
Read inputs for segment 5
Compute number of aircraft required
Compute number of aircraft available
1
3
1
Is aircraft requirement ≤ availability ?
Yes
No
Compute number of simulators required
Compute number of simulators available
2
Compute number of aircraft procured
2
Is simulator requirement ≤ availability ?
Yes
No
Compute number of simulators procured
Are computations for all bases, phases and years made?
Yes
No
3
Print equipment output
To segment 6

Fig. 29—Simplified flow diagram of Segment Five: Equipment

of aircraft lost through attrition, and the addition of aircraft in such numbers as are specified by the user of the model. The available inventory is then compared with the requirement. If the available inventory is thenfficient, the model calculates the additional aircraft that must be procured to fill the shortage.

The treatment of simulators is similar to that of aircraft. One difference is that there is no attrition. The other difference is that the number of simulators is determined separately for each base, whereas the aircraft requirement is computed for the UPT program as a whole. This is done because simulators are fixed pieces of equipment and, unlike aircraft, cannot be moved readily from one base to another.

SEGMENT 6: FACILITIES

Facility requirements, other than new bases and runways,[*] are determined in Segment 6. Figure 30 shows a simplified diagram of this segment.

The floor space requirement for simulators is determined from the number of simulators on the base and the square footage requirement per simulator. Classroom area requirements are based on a square footage requirement per student. Simulator and classroom facility requirements are both compared with the area available. Any additional amount needed is added by the model.

Other facility requirements are specified by the user. These include the facilities required for flight briefings, called "flying training basic buildings," and airmen dormitories, bachelor officer quarters, and family housing.

SEGMENT 7: COST

In Segment 7, the estimated costs of UPT are calculated from the resource requirements computed in the previous segments. A simplified flow diagram of this segment appears in Fig. 31. Cost items will be discussed in the order in which they appear in the output tables. This

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[*] Bases and runways are computed in Segment 3.

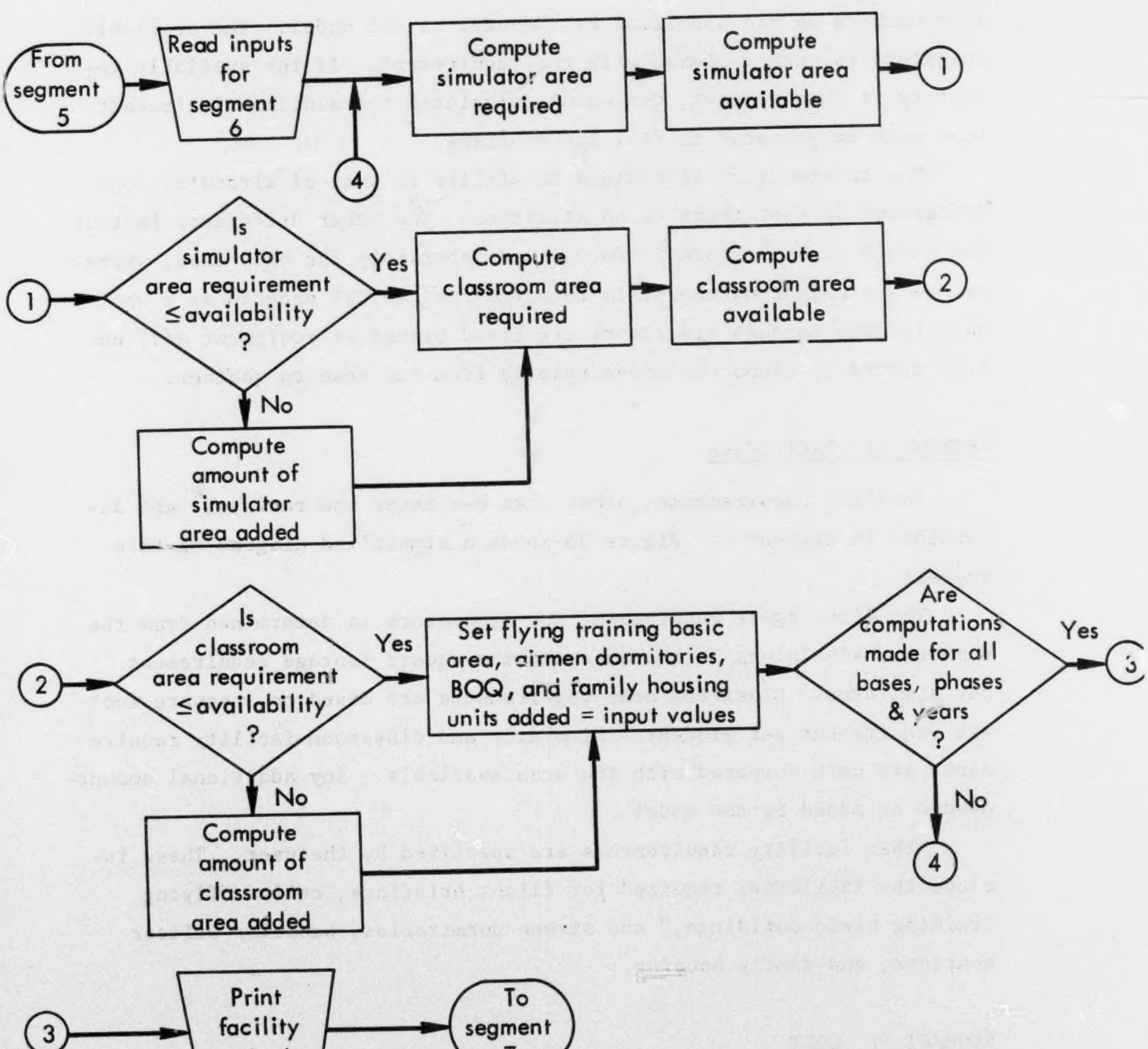
From segment 5
Read inputs for segment 6
Compute simulator area required
Compute simulator area available
1
4
1
Is simulator area requirement ≤availability ?
Yes
Compute classroom area required
Compute classroom area available
2
No
Compute amount of simulator area added
2
Is classroom area requirement ≤availability ?
Yes
Set flying training basic area, airmen dormitories, BOQ, and family housing units added = input values
Are computations made for all bases, phases & years ?
Yes
3
No
Compute amount of classroom area added
No
4
3
Print facility output
To segment 7

Fig. 30—Simplified flow diagram of Segment Six: Facilities

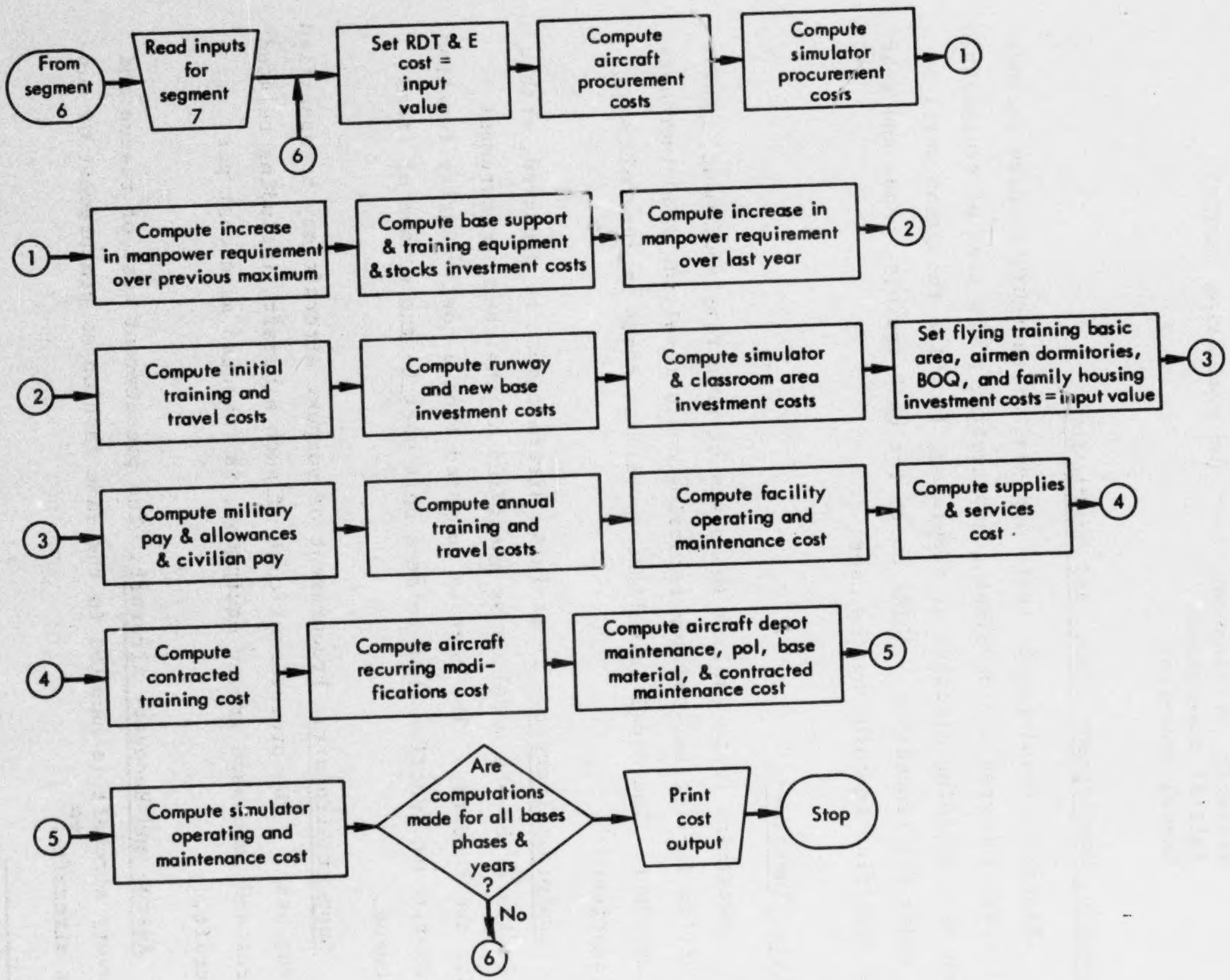
From segment 6
Read inputs for segment 7
Set RDT & E cost = input value
Compute aircraft procurement costs
Compute simulator procurement costs
1
6
Compute increase in manpower requirement over previous maximum
Compute base support & training equipment & stocks investment costs
Compute increase in manpower requirement over last year
2
Compute initial training and travel costs
Compute runway and new base investment costs
Compute simulator & classroom area investment costs
Set flying training basic area, airmen dormitories, BOQ, and family housing investment costs = input value
3
Compute military pay & allowances & civilian pay
Compute annual training and travel costs
Compute facility operating and maintenance cost
Compute supplies & services cost
4
Compute contracted training cost
Compute aircraft recurring modifications cost
Compute aircraft depot maintenance, pol, base material, & contracted maintenance cost
5
Compute simulator operating and maintenance cost
Are computations made for all bases phases & years ?
No
Print cost output
Stop

Fig. 31—Simplified flow diagram of Segment Seven: Cost

ordering differs somewhat from the order shown in Fig. 31. Costs fall into three general categories:

Research, development, test and evaluation (RDT&E)
Initial investment
Annual operating

Research, Development, Test, and Evaluation

Research, development, test, and evaluation (RDT&E) costs include all costs incurred for developing and testing a new item of equipment, such as a training aircraft or simulator, from its inception until it is ready for production. RDT&E costs for each training phase and year are specified in total by the user.

Initial Investment

Investment costs include the costs of procuring equipment, constructing facilities, and non-recurring costs resulting from increases in manpower. The model calculates investment costs in the following categories:

Training Aircraft. If training aircraft must be procured, either as indicated by the model or as specified by the user, procurement costs are incurred. The cost is computed from a cost-quantity function, a logarithmic function that relates unit cost to the number of items procured.

Support Aircraft. Procurement of support aircraft may be specified by the user.* The procurement cost of such aircraft, including related spares and aerospace ground equipment, is computed as a cost per aircraft.

Rescue and Recovery Aircraft. The procurement cost of rescue and recovery aircraft is handled in the same fashion as procurement of support aircraft.**

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*No support aircraft are currently being used.

**HH-43 helicopters are currently being used for rescue and recovery.

Training Aircraft Spares. Included in this category is the initial stock of spare parts needed to maintain the training aircraft. It is computed as a percentage of the investment cost for training aircraft.

Aerospace Ground Equipment. Aerospace ground equipment (AGE) includes equipment and associated spare parts used to refuel, service, and tow the aircraft and to test aircraft components. The total AGE cost is computed as a percentage of the investment cost for training aircraft.

Simulators. Simulators may be procured either as indicated by the model or as specified by the user of the model. In either case, the procurement cost is computed as a cost per simulator procured.

Simulator Spares. Included in this category is the initial stock of spare parts needed to maintain the simulators. It is computed as a percentage of the investment cost for simulators.

Training Equipment. Equipment used to train students ranges from audio-visual training aids to parachute jump platforms and altitude chambers. If the average number of students on the base increases above the initial number, training equipment costs are incurred. The cost is computed as an amount per increase in the student load over the initial number. In other words, it is assumed that there is enough equipment available to train the number of students in the first year, but if the student load exceeds this level, additional equipment will be needed.

Base Support Equipment. Costs are similarly computed for base support equipment if the total military manpower of the base increases over the initial level. Base support equipment includes all equipment used on the base in support of the training mission from typewriters to motor vehicles.

Facilities: New Base Conversion. Included in this category are all costs associated with opening a new UPT base. The category is called "New Base Conversion" to emphasize that a new UPT base is generally obtained by converting an existing base rather than constructing a new base. Costs of conversion include constructing new buildings, converting existing buildings to other uses, and repairing facilities. The total of these costs is specified by the user of the model.

Facilities: Runways. The costs of a runway, including lighting and all related costs, are specified by the user for each base and phase. If a runway is added, that cost is incurred.

Facilities: Simulator Buildings.* The cost of a simulator area, whether the area is added by the model or by the user of the model, is calculated on a cost-per-square-foot basis.

Facilities: Classroom Buildings.* Costs of classrooms, whether they are added by the model or by the user, are calculated on a cost-per-square-foot basis, also.

Facilities: Flying Training Basic Buildings.* These facilities are used for pre-flight and post-flight briefings and for storage of students' flight gear. Costs for additions to these facilities are specified by the user of the model.

Facilities: Housing. Costs for airmen dormitories, bachelor officer quarters, and family housing units are also specified by the user.

Facilities: Other. Costs of any additional facilities that are not included within any of the above categories are also specified by the user.

Stocks. Stocks are inventories of such things as aircraft fuel, facility maintenance materials, and office supplies. Stocks costs are computed as a cost per increase in military persons over the beginning number.

Initial Training. Initial training costs will usually be limited to the costs of training that is given to military personnel in preparation for their assignment to a pilot training base as a member of its permanent party complement.[*] If the number of permanent party officers or airmen increases from one year to the next, the cost of any preparatory courses is a cost properly chargeable to UPT. For example, an increase in aircraft flying hours would require an increase in aircraft maintenance personnel. Some, if not all, of these personnel would receive training in aircraft maintenance at an ATC technical training center immediately prior to their being assigned to the pilot training base. The cost of these preparatory courses is a UPT cost.

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*Simulator, classroom, and flying training basic facilities are designated, in the model, as "simulator buildings," "classroom buildings," and "flying training basic buildings," but any of these facilities may be situated under one roof with other facilities.

Although the strong probability is that the users of the model will elect to charge, to initial training, only the courses that are directly related to the permanent party member's current duty assignment, the model does not impose any such limitation. The user may consider, for example, that basic military training of newly-assigned airmen and precommissioning training of newly-assigned officers should be included in the initial training cost occasioned by the increase in permanent party strength.

The user of the model develops an average initial training cost per officer and an average per airman to reflect whatever assumptions he makes regarding costs to be included in initial training. These averages are entered as inputs and the model then calculates the total training cost by multiplying the average per officer and average per airman by the number of personnel of each category that is added to the permanent party.

Initial Travel. When the permanent party strength of a UPT base is increased, a cost is incurred for the permanent change of station (PCS) move of the newly-assigned officer or airman. One cost factor is input for all officers; another for all airmen. These are averages and consequently are applied to all PCS movements irrespective of the training base involved. The user of the model may use such factors, for officers and airmen, respectively, as he considers appropriate, i.e., he may compute an average cost for each of the two categories from data available to him or he may elect to use published PICS cost averages, e.g., from AFM 172-3, USAF Cost and Planning Factors or from the ATC Cost Factors Summary.

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[*] Permanent party personnel are military personnel assigned for continuing duty at the training base. Students are not included.

Annual Operating

Annual Operating costs are costs incurred to operate and maintain equipment and facilities, and recurring personnel-related costs such as pay and allowances.

Recurring Modifications. Recurring modifications costs result from modifications made to the training aircraft after they have been procured. Such costs are computed as an annual percentage of the investment cost for training aircraft.

Training Aircraft Maintenance: Depot Maintenance. Depot maintenance is the maintenance that occurs at a central maintenance facility rather than at the base. Depot maintenance costs are calculated on the basis of the cost per flying hour of training aircraft.

Training Aircraft Maintenance: Base Material. Base materials are those aircraft maintenance materials consumed at base level. Their costs are computed on the basis of the cost per flying hour of training aircraft.

Training Aircraft Maintenance: Contracted Maintenance. This category covers the cost of any contracted, base-level aircraft maintenance. It is computed on the basis of the cost per flying hour of training aircraft.

Training Aircraft POL. Petroleum, oil, and lubricants (POL) costs also are computed on the basis of the cost per flying hour of training aircraft.

Support Aircraft Operation and Maintenance. Support aircraft operation and maintenance costs include depot maintenance, base materials, contracted maintenance, and POL for support aircraft. The total of these costs is calculated on the basis of the cost per flying hour of support aircraft.

Rescue and Recovery Aircraft Operation and Maintenance. Costs for rescue and recovery aircraft operation and maintenance include the same items and are calculated in the same manner as costs for support aircraft operation and maintenance.

Simulator Materials and Services. These costs are for materials and contracted services used for maintenance of simulators. They are computed as an annual percentage of the investment cost for simulators.

Facilities Materials and Services. Costs include materials and services used for maintaining base facilities; they are calculated as a fixed cost plus a cost per military person.

Contracted Flying Training. This category represents the cost of any flying training performed by a contractor.* Costs for contracted flying training are computed on the basis of a cost per hour flown under contracted training.

Pay and Allowance: Officers, Airmen, and Civilians. Pay and allowances are computed on the basis of the average costs per officer, per airmen, and per civilian.

Annual Training. Normal personnel turnover requires that replacement personnel be trained each year. Turnover, in this sense, refers to the replacement by new personnel of permanent-party officers and airmen leaving the Air Force. The cost of the training received by the new personnel is included in annual training. The average training costs per officer and airman used to calculate initial training costs are used for calculating annual training costs. (See page 74.) The numbers of officers and airmen lost due to turnover is calculated from a turnover factor for each category. Then the training costs per officer and airman are multiplied by the numbers of losses.

Annual Travel. This category includes the costs of moving the newly-trained replacement personnel to the UPT base. Such costs are computed by multiplying the number of officers, excluding students, and airmen by the turnover factors, and then multiplying the numbers of losses by the travel costs per officer and airmen used to calculate "initial travel" costs (see page 75). Also included in this category are the travel costs of moving the new UPT student to the training base. This cost is computed by multiplying the number of entries determined in Segment 1 by the average travel cost per officer.

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*Presently, all Phase I flight training is contracted.

Supplies and Services. Supplies and services include materials, supplies, and contractual services for such functions as base administration, supply operations, food and medical services, and operations and maintenance of base support equipment. Costs for all supplies and services are computed on a cost-per-military-man basis.

VI. CONCLUSION

The UPT-simulation model described in this Memorandum is intended to be used as an aid in estimating the resources and costs of alternative ways of conducting UPT. Estimating relationships and equations are discussed and presented in simplified diagrams. The computer program described in Volume V, A User's Guide to the Undergraduate Training Computer Cost Model, has been tested extensively and the results have been checked against data and estimates provided by the Air Training Command.

A base case set of inputs--all of the inputs required to simulate the current UPT system--has been assembled. Alternatives to the present system are easily examined by changing only the input values that vary from the base case. Many alternatives have been examined, and some of the results are presented.

This model, used alone or in conjunction with the other models developed in the Pilot Training Study, will facilitate long-range planning and analysis of pilot training.

Appendix A-I

W. E. Mooz

SURVIVAL SCHOOL

Every Air Force flight crew faces the possibility of having to make a forced landing because of some untoward contingency such as bad weather, equipment malfunction, becoming lost, running out of fuel, or being hit by enemy gunfire. A forced landing may place the crew in a physically-hostile environment, such as the arctic, desert, or sea, or it may put them down in a politically-hostile territory. Further, the difficulty of survival may be compounded by physical injuries sustained in the landing.

Survival from a forced landing may, therefore, depend upon the ability of the crew or individual airmen to obtain food and shelter and security from enemies; to administer first aid, and to find a way to rejoin friendly forces. For this reason, the Air Force operates a Survival School that provides the basic course with which this study is concerned.*

Because basic survival training is mandatory for all flight crews, the cost of the training is a part of the cost of producing a pilot. The object of this study, therefore, is to produce methodology for estimating the cost of basic survival training for pilots, and for conducting cost sensitivity analyses.

DESCRIPTION

The USAF Survival School is an activity of the Air Training Command (ATC). Classroom and living accommodations are located at Fairchild Air Force Base, a Strategic Air Command (SAC) base situated about 11 miles from Spokane, Washington. The Survival School is operated by the 3636th Combat Crew Training Group (Survival) of ATC. It has an authorized strength of 33 officers, 347 enlisted personnel, and 12 civilians.

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*The Survival School also provides specialized courses: two for instructors and two that deal with survival situations peculiar to particular global areas.

Under the host-tenant agreement between SAC and ATC, Fairchild AFB provides the Survival School with all normal housekeeping support. For this reason, the 3636th CCTG consists almost entirely of instructors and administrative personnel. The school staff is organized as shown in Fig. 32.

The school's mission is to train flight crews in the art of survival. Table 1 shows the curriculum, the course lengths, and the number of students who graduated from each of the six courses during the first six months of fiscal year 1968.

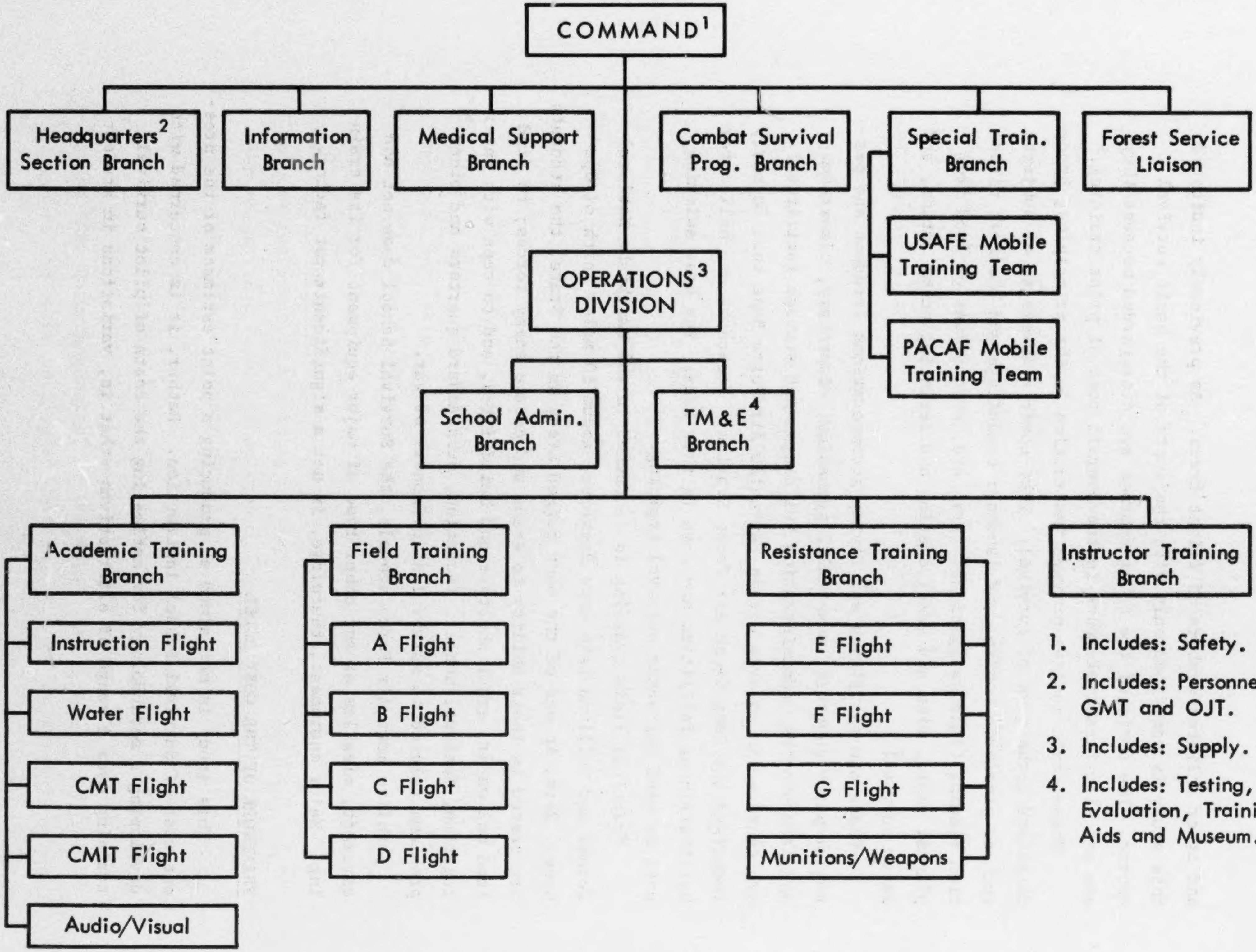
Table 1

SURVIVAL SCHOOL CURRICULUM AND GRADUATES
FIRST HALF OF FISCAL YEAR 1968

			Graduates 1st Half 1968	
Number	Type	Length	Number	Percent
S-V80-A	Basic	15 days	2162	43.0
S-V85-A	Basic (short)	9 days	2153	43.6
Subtotal			4315	87.5
S-V82-A	Special	5 days	234	4.8
S-V83-A	Advanced	5 days	245	5.0
S-V81-A	Instructor	6 months	35	0.7
S-V84-A	Instructor (Combative measures)	5 weeks	98	2.0
Total			4927	100.0

The basic survival course is given in two versions: a standard-length course requiring 15 training days, and a short course requiring nine. Because the level of production was the same in the second half of the year as in the first, each of these basic courses produced upwards of 4300 graduates during fiscal year 1968. Attrition from the basic courses is negligible, and none is programmed.

Pilots and other rated officers (e.g., navigators, electronic warfare officers, and radar intercept officers) constitute about 65 percent of the basic course student load. The remainder is made up of crew chiefs, tail gunners, loadmasters, boom-operators, radio operators,


COMMAND1
Headquarters2 Section Branch
Information Branch
Medical Support Branch
Combat Survival Prog. Branch
Special Train. Branch
Forest Service Liaison
USAFE Mobile Training Team
PACAF Mobile Training Team
OPERATIONS3 DIVISION
School Admin. Branch
TM & E4 Branch
Academic Training Branch
Instruction Flight
Water Flight
CMT Flight
CMIT Flight
Audio/Visual
Field Training Branch
A Flight
B Flight
C Flight
D Flight
Resistance Training Branch
E Flight
F Flight
G Flight
Munitions/Weapons
Instructor Training Branch

1. Includes: Safety.
2. Includes: Personnel, GMT and OJT.
3. Includes: Supply.
4. Includes: Testing, Evaluation, Training Aids and Museum.

Fig. 32—3636 Combat Crew Training Group (Survival)

and other enlisted members of flight crews. As previously indicated, this study is concerned only with the costs of the basic survival course. The costs of the other courses are disregarded because they are not significant elements in the overall cost of pilot training.

These basic courses provide instruction in the principles, procedures and techniques of survival. They cover a diversity of subjects such as parachute control and landing; camouflage and shelter; direction finding (land navigation); first aid; procurement of food from plants, roots, fish and game; evading and resisting enemy action, and water survival.

Classroom facilities and living accommodations (student and permanent party quarters, mess hall, gymnasium, dispensary, classrooms and laboratories, administration buildings, and storage facilities) are centered in an area within Fairchild Air Force Base that formerly comprised the Deep Creek Air Force Station. Parachute and helicopter hoist training facilities are also in this area. The base swimming pool is used for water survival training.

Practical field training is conducted in the Kanikiska National Forest and Sullivan Lake Game Preserve, about 60 miles north of Spokane. Here, in one of the most rugged areas in the State, the students are tested in their ability to evade and escape enemy forces; to find food and water, erect shelters and build fires, and to cope with interrogation, fatigue, hunger, isolation, substandard quarters and other problems related to survival as prisoners of war.

Unlike most Air Force schools, the Survival School does not use aircraft, missiles or any other type of major equipment for its training. Major equipment, therefore, is not a significant cost factor.

FRAMEWORK OF THE COST MODEL

This study is not aimed at producing a point estimate of the present cost of Survival School instruction. Rather, it is concerned with developing a methodology for estimating the costs of pilot survival training over a range of alternatives--that is, variations in student loads, course lengths and ratio of instructors to students.[*] The absence of major equipment costs simplifies this task by reducing it to the identification of the numbers and types of personnel required for the operation of the school and to the identification of the measures of the facilities costs associated with school activities.

Facilities costs are a function of the number of personnel. Normally, in cost-estimating models, personnel are categorized as operating, maintenance, administrative, and support personnel. However, since there is no item of major equipment at the Survival School, there is no requirement for maintenance personnel. This reduces the personnel categories to:

(a) Operating Personnel. For purposes of this study, this category includes students and all academic personnel--i.e., instructors and other members of the Operations Division as depicted on the 3636th CCTG organization chart, Fig. 1.

(b) Administrative Personnel. Includes all personnel shown above the Operations Division block, Fig. 1.

(c) Support Personnel. Includes civil engineer, supply, air police, food service, and all other base operating support personnel of Fairchild AFB. These personnel are assigned to SAC, the host command, but a portion of their costs is properly chargeable to the Survival School.

As previously stated, this study is concerned only with pilots and with the basic survival courses S-V80-A and S-V85-A (Table 1). Because the school teaches additional courses and includes all categories of flight crew personnel, the costs of some school personnel are attriutable to the school as a whole. That is, some personnel costs cannot be identified as functions of the number of pilots in the student body, the number of basic-course student days or the number of pilots taking the basic courses. For example, the school commander and his immediate staff are an administrative group that is fixed in number. The size of this group is independent both of the total number of students and of the relative proportion of any category of student in any of the courses offered. Similarly, the number of instructors required for the basic courses is independent of the distribution of students between pilots and other student categories.

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[*] These are the only significant variables. Unlike other pilot training courses, there are no syllabus constituents, such as flying, which can be altered to produce marked changes in training costs.

The staff of the Survival School is typical of the staff of most Air Force schools; that is, it is composed of a fixed number of personnel plus personnel that vary in number as a function of workload. Less typical is the fact that the school offers several courses and that each class is made up of several categories of both officer and enlisted students.

The fixed costs must be considered in determining total school costs, the cost of a particular course or the average cost per pilot. They need not be considered in determining the incremental or decremental costs of varying the pilot load because this involves only the costs that are variable.

The model has been designed to permit allocations of fixed personnel costs if the user desired. The model is, therefore, responsive to questions involving either total or incremental costs.

Figure 33 is a general, highly-aggregated flow chart illustrating the framework of the model. It is essentially a personnel estimating model because, in the absence of any major equipment, each resource and cost category is a function of the number of school personnel (instructors, supervisors and administrators), support personnel and students.

Listings of FORTRAN and JOSS* computer programs appear in Sections A-II and A-III, respectively.

EFFECT OF VARIABLES ON COSTS

The Survival School is an inexpensive and relatively simple school in comparison with other courses for pilot training. To reiterate,

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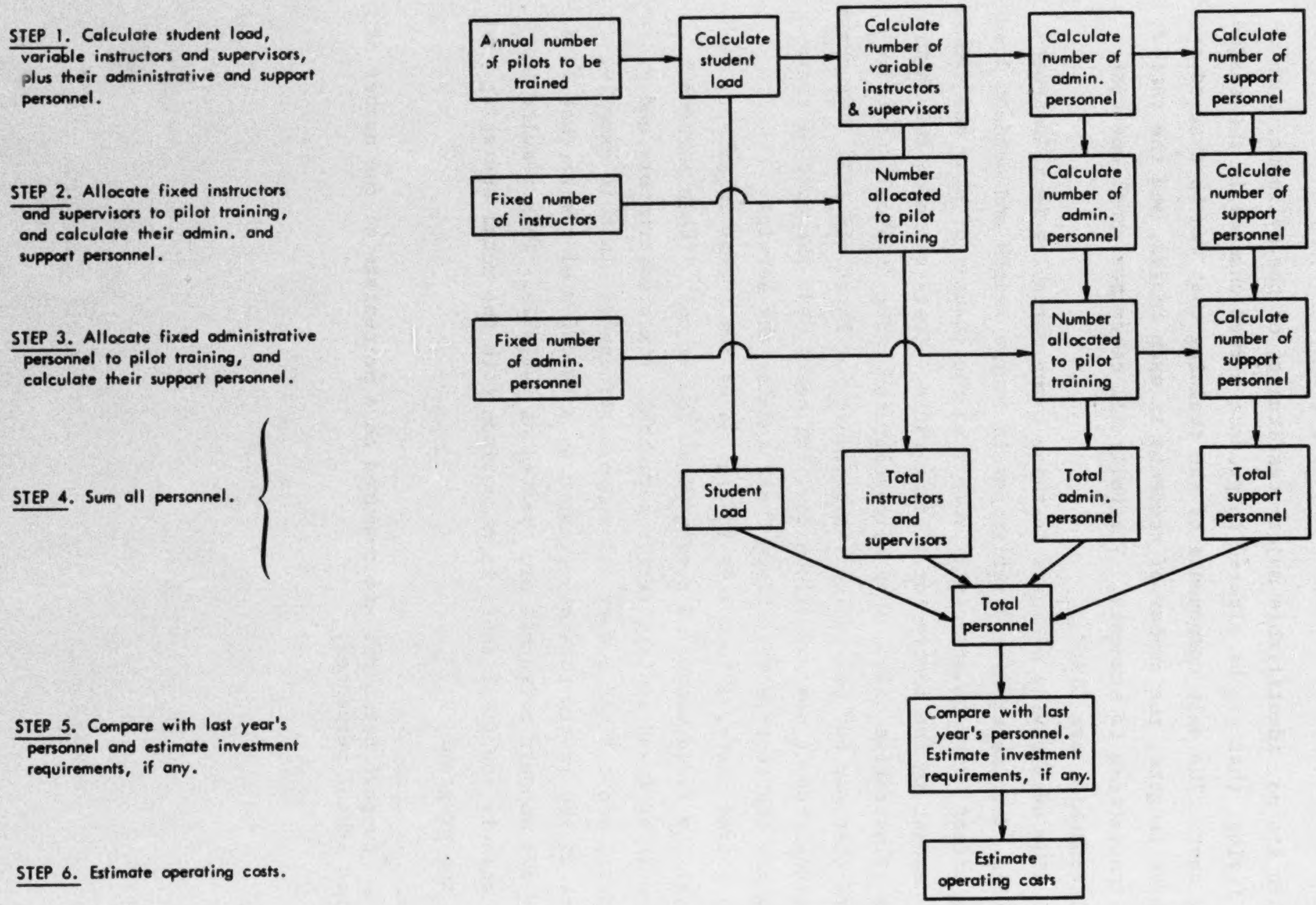
*JOSS is the trademark and service mark of The Rand Corporation for its computer program and services using that program.



STEP 1. Calculate student load, variable instructors and supervisors, plus their administrative and support personnel.

STEP 2. Allocate fixed instructors and supervisors to pilot training, and calculate their admin. and support personnel.

STEP 3. Allocate fixed administrative personnel to pilot training, and calculate their support personnel.

STEP 4. Sum all personnel.

STEP 5. Compare with last year's personnel and estimate investment requirements, if any.

STEP 6. Estimate operating costs.

Annual number of pilots to be trained
Calculate student load
Calculate number of variable instructors & supervisors
Calculate number of admin. personnel
Calculate number of support personnel
Fixed number of instructors
Number allocated to pilot training
Calculate number of admin. personnel
Calculate number of support personnel
Fixed number of admin. personnel
Number allocated to pilot training
Calculate number of support personnel
Student load
Total instructors and supervisors
Total admin. personnel
Total support personnel
Total personnel
Compare with last year's personnel. Estimate investment requirements, if any.
Estimate operating costs

Fig. 33—Framework of the survival school cost model

there are no identifiable major constituents of the syllabus, such as flying, that can be altered to produce marked changes in the training cost. The only components of the training that can be changed are course lengths, the number of students in each course, and the ratio of instructors to students. Virtually all other personnel and cost relationships are fixed.

The sensitivity of costs to these three variables is illustrated in Fig. 34. As expected, variations in course length and student loading affect costs substantially more than the changes of plus and minus 50 percent in the instructor-student ratio. Costs shown on the chart are illustrative only. They were generated using "typical" cost factors that may not be precisely applicable for Fairchild AFB. The costs include student pay and allowances, TDY costs, and the cost of training new instructors to replace those leaving the service.

Fixed costs, illustrated in Fig. 34 as the Y axis intercept, reflect the fixed number of personnel at the school. These personnel consist of fixed administrative personnel, fixed instructors and supervisors, and a fixed number* of support personnel. In this example, most of the instructors are treated as a function of the student load, and all support personnel are treated as variable. This results in relatively low fixed costs in comparison with the total operating cost of the program.

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*Support personnel are computed as a percentage of the number of fixed school personnel.

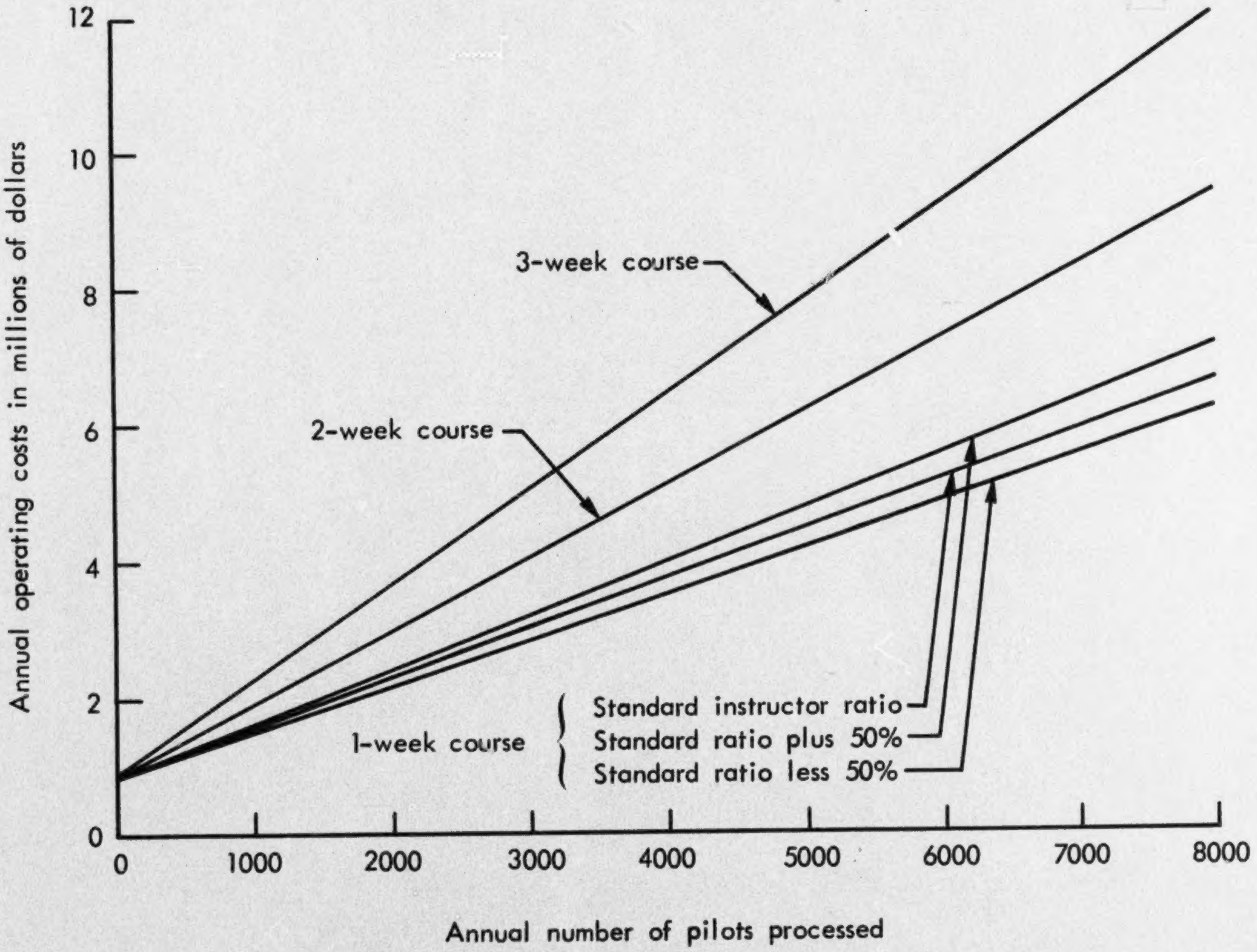

Fig. 34—Survival school operating costs as a function of course length, number of students and ratio of instructors to students

Appendix A-II

LISTING OF SURVIVAL SCHOOL FORTRAN IV(360/65) PROGRAM

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C      COST ESTIMATES--USAF SURVIVAL SCHOOL
C
       COMMON     A1(21),A2(21),A3(21),A4(21),A5(21),A6(21),A7(21),A8(21),
      1A9(21),A10(21),A11(21),A12(21),A13(21),A14(21),A15(21),A16(21),
      1A17(21),A18(21),A19(21),A20(21),A21(21),A22(21),A23(21),A24(21),
      1A25(21),A26(21),A27(21),A28(21),A29(21),A30(21),A31(21),A32(21),
      1A33(21),A34(21),A35(21),A36(21),A37(21),A38(21),A39(21),A40(21),
      1A41(21),A42(21)
       COMMON     A43(21),A44(21),A45(21),A46(21),A47(21),A48(21),A49(21),
      1A50(21),A51(21),A52(21),A53(21),A54(21),A55(21),A56(21),A57(21),
      1A58(21)
       COMMON     P1(21),P2(21),P4(21),P5(21),P6(21),P7(21),P8(21),P9(21),
      1P3(21),P10(21),P11(21),P12(21),P13(21),P14(21),P15(21),P16(21),
      1P17(21),P18(21),P19(21),P20(21),P21(21),P22(21),P23(21),P24(21),
      1P25(21),P26(21),P27(21),P28(21),P29(21),P30(21),P31(21),P32(21),
      1P33(21),P34(21),P35(21),P36(21),P37(21),P38(21),P39(21),P40(21),
      1P41(21),P42(21),P43(21),P44(21),P45(21),P46(21),P47(21),P48(21),
      1P49(21),P50(21),P51(21),P52(21),P53(21),P54(21),P55(21),P56(21),
      1P57(21),P58(21),P59(21),P60(21),P61(21),P62(21),P63(21),P64(21),
      1P65(21),P66(21),P67(21),P68(21),P69(21),P70(21),P71(21),P72(21),
      1P73(21),P74(21),P75(21),P76(21),P77(21),P78(21),P79(21),P80(21),
      1P81(21), P82(21), CI(21), CO(21), V(21), W(21), NYEAR(21),
      1FILLER(5)
C
C      READ IN DUMP PRINTOUT DESIGNATOR, IDUMP (0 DON T PRINT DUMP, 1 PRINT DUMP)
C
       DO 400 I=1, 3050
  400 A1(I)=0.
       READ (5,1) IDUMP
    1 FORMAT (I1)
       WRITE (6,90)
C
C      READ DATA BY YEAR        A1 THROUGH A57 AND THE YEAR
C
    2 J = 1
    3 J=J+1
       READ (5,5)  A1(J),A2(J),A3(J),A4(J),A5(J),A6(J),A7(J),A8(J),A9(J),
      1A10(J),A11(J),A12(J),A13(J),A14(J),A15(J),A27(J),        A29(J),
      1A30(J),A32(J),A33(J),A34(J),A35(J),A36(J),A37(J),A38(J),A40(J),
      1A42(J),A43(J),A44(J),A45(J),A46(J),A47(J),A48(J),        A49(J),
      1A50(J),A51(J),A52(J),A53(J),A54(J),A55(J),A56(J),A57(J),NYEAR(J),
      1IEND
    5 FORMAT (7F10.2/7F10.2/7F10.2/7F10.2/7F10.2/7F10.2,2X,I4,3X,I1)
       IF (IEND .NE. 1) GO TO 3
C
C      READ IN P18, P1, AND P19 OF THE PREVIOUS YEAR
C
       N = J
       READ (5,6) P18(1),P1(1),P19(1),A28(1),A31(1),A39(1),A41(1),A58(1)
    6 FORMAT (7F10.2/F10.2)
C
C      DATA HAS BEEN READ--NOW DO CALCULATIONS
C
       DO 20 L=2,N
       P1(L)=A1(L)*A2(L)/52.143
       P2(L)=P1(L)*(A3(L)+A4(L))
      P3(L)=A9(L)*A5(L)
      P4(L)=A6(L)*(P1(L)+P2(L))
      P5(L)=P3(L)*A6(L)
      P6(L)=A7(L)*A10(L)
      P7(L)=A8(L)*(P1(L)+P2(L)+P4(L))
      P9(L)=A8(L)*(P3(L)+P5(L))
      P10(L)=A8(L)*P6(L)
      P8(L)=A11(L)*(P7(L)+P9(L)+P10(L))
      P11(L)=A12(L)*(P7(L)+P9(L)+P10(L))
      P12(L)=P7(L)+P9(L)+P10(L)-P8(L)-P11(L)
      P13(L)=A13(L)*(P4(L)+P5(L)+P6(L))
      P14(L)=A14(L)*(P4(L)+P5(L)+P6(L))
      P15(L)=P4(L)+P5(L)+P6(L)-P13(L)-P14(L)
      P16(L)=A15(L)*(P2(L)+P3(L))
      P17(L)=P2(L)+P3(L)-P16(L)
      P18(L)=P1(L)+P16(L)+P13(L)+P8(L)
      P19(L)=P11(L)+P14(L)+P17(L)
      P20(L)=P12(L)+P15(L)
      P21(L)=P18(L)+P19(L)
      P22(L)=P20(L)+P21(L)
C
C     CALCULATE INVESTMENT COSTS
C
      P49(L)=P1(L)*A27(L)
      IF (P49(L).GT.A28(L-1)) GO TO 30
      P51(L)=0.0
      A28(L)=A28(L-1)
      GO TO 35
   30 P50(L)=P49(L)-A28(L-1)
      P51(L)=P50(L)*A29(L)
      A28(L)=A28(L-1)+P50(L)
   35 P52(L)=P1(L)*A32(L)
      IF (P52(L).GT.A31(L-1)) GO TO 40
      P53(L)=0.0
      A31(L)=A31(L-1)
      GO TO 45
   40 P53(L)=P52(L)-A31(L-1)
      A31(L)=A31(L-1)+P53(L)
   45 P55(L)=((P18(L)-P1(L))-(P18(L-1)-P1(L-1)))
      IF (P55(L).GT.0.0) GO TO 50
      P56(L)=0.0
      P57(L)=0.0
      GO TO 55
   50 P56(L)=P55(L)*A33(L)
      P57(L)=P55(L)*A34(L)
   55 P58(L)=P19(L)-P19(L-1)
      IF (P58(L).GT.0.0) GO TO 60
      P59(L)=0.0
      P60(L)=0.0
      GO TO 65
   60 P59(L)=P58(L)*A35(L)
      P60(L)=P58(L)*A36(L)
   65 P61(L)=P21(L)*A37(L)
      IF (P61(L).GT.A58(L-1)) GO TO 66
      P82(L)=0.
      A58(L)=A58(L-1)
      GO TO 67
   66 P82(L)=P61(L)-P58(L-1)
      A58(L)=P61(L)
   67 P63(L)=P62(L)*A38(L)
      IF (P63(L).LE.A39(L-1)) GO TO 70
      P64(L)=P63(L)-A39(L-1)
      A39(L)=A39(L-1)+P64(L)
      GO TO 68
   70 P64(L)=0.
      A39(L)=A39(L-1)
   68 P65(L)=P1(L)*A40(L)
      IF (P65(L).GT.A41(L-1)) GO TO 80
      P66(L)=0.0
      A41(L)=A41(L-1)
      GO TO 85
   80 P66(L)=(P65(L)-A41(L-1))*A42(L)
      A41(L)=P65(L)
C
C     ANNUAL OPERATING COSTS
C
   85 P67(L)=P21(L)*A43(L)
      P68(L)=P21(L)*A44(L)
      P69(L)=P21(L)*A45(L)
      P70(L)=P21(L)*A46(L)
      P71(L)=P1(L)*A47(L)
      P72(L)=(P18(L)-P1(L))*A48(L)
      P73(L)=P19(L)*A49(L)
      P74(L)=P20(L)*A50(L)
      P75(L)=(P18(L)-P1(L))*A51(L)*A52(L)
      P76(L)=A53(L)*A54(L)*P19(L)
      P77(L)=A1(L)*A55(L)
      P78(L)=A52(L)*A56(L)*(P18(L)-P1(L))
      P79(L)=A54(L)*A57(L)*P19(L)
      P80(L)=P51(L)+P53(L)+P56(L)+P57(L)+P59(L)+P60(L)+P82(L)+P64(L)+
     1P66(L)
      P81(L)=P67(L)+P68(L)+P69(L)+P70(L)+P71(L)+P72(L)+P73(L)+P74(L)+
     1P75(L)+P76(L)+P77(L)+P78(L)+P79(L)
      CO(L)=P81(L)/1000.0
      CI(L)=P80(L)/1000.0
   20 CONTINUE
C
C     PRINT P8,P11,P12,P13,P14,P15,P16,P17,P1,P18,P19,P20,P21,P22
C
      PRINT 90
   90 FORMAT (1H1)
   91 FORMAT (1H )
      NN=N
      MM=2
      IF ((N-1).GT.10) NN=11
C
C     PRINT YEARS INVOLVED
C
 1000 PRINT 92,(NYEAR(K),K=MM,NN)
   92 FORMAT (9X,4HYEAR,10(6X,I4))
      PRINT 91
C
```

```
C      PRINT BOS OFFICERS
C
       PRINT 93,(P8(K),K=MM,NN)
    93 FORMAT (1X,12HBOS OFFICERS,10(4X,F6.1))
       PRINT 91
C
C      PRINT BOS AIRMEN
C
       PRINT 94,(P11(K),K=MM,NN)
    94 FORMAT (1X,13HBOS AIRMEN---,2X,F6.1,9(4X,F6.1))
       PRINT 91
C
C      PRINT BOS CIVILIANS
C
       PRINT 95,(P12(K),K=MM,NN)
    95 FORMAT (1X,13HBOS CIVILIANS,2X,F6.1,9(4X,F6.1))
       PRINT 91
C
C      PRINT ADMINISTRATIVE OFFICERS
C
       PRINT 97,(P13(K),K=MM,NN)
    97 FORMAT (1X,12HADM OFFICERS,10(4X,F6.1))
       PRINT 91
C
C      PRINT ADMINISTRATIVE AIRMEN
C      PRINT NUMBER OF (3) AIRMEN CHARGED TO PILOTS
C
       PRINT 99,(P14(K),K=MM,NN)
    99 FORMAT (1X,10HADM AIRMEN   ,10(4X,F6.1))
       PRINT 91
C
C      PRINT ADMINISTRATIVE CIVILIANS
C
       PRINT 101,(P15(K),K=MM,NN)
   101 FORMAT (1X,12HADM CIVILIAN,10(4X,F6.1))
       PRINT 91
C
C      PRINT INSTRUCTOR AND SUPERVISOR OFFICERS
C
       PRINT 103,(P16(K),K=MM,NN)
   103 FORMAT (1X,12HINST+SUP OFF,10(4X,F6.1))
       PRINT 91
C
C      PRINT INSTRUCTOR AND SUPERVISOR AIRMEN
C
       PRINT 105,(P17(K),K=MM,NN)
   105 FORMAT (1X,12HINST+SUP AMN,10(4X,F6.1))
       PRINT 91
C
C      PRINT STUDENT LOAD
C
       PRINT 106,(P1(K),K=MM,NN)
   106 FORMAT (1X,15HSTUDENT LOAD   ,10(4X,F6.1))
       PRINT 91
C
C      PRINT TOTAL OFFICERS/YEAR
```

```
C
      PRINT 108,(P18(K),K=MM,NN)
  108 FORMAT (1X,15HTOTAL OFFICERS,2X,F6.1,9(4X,F6.1))
      PRINT 91
C
C     PRINT TOTAL AIRMEN/YEAR
C
      PRINT 109,(P19(K),K=MM,NN)
  109 FORMAT (1X,12HTOTAL AIRMEN,4X,F6.1,9(4X,F6.1))
      PRINT 91
C
C     PRINT TOTAL CIVILIANS/YEAR
C
      PRINT 110, (P20(K),K=MM,NN)
  110 FORMAT (1X,12HTOTAL CIVIL.,4X,F6.1,9(4X,F6.1))
      PRINT 91
C     PRINT TOTAL MILITARY
      PRINT 102,(P21(K),K=MM,NN)
  102 FORMAT (1X,12HTOT MILITARY,10(4X,F6.1))
C     PRINT TOTAL PERSONNEL
      PRINT 104,(P22(K),K=MM,NN)
  104 FORMAT (1X,12HTOTAL PERSON,10(4X,F6.1))
C
C     PRINT TOTAL INVESTMENT COST
C
      PRINT 111
  111 FORMAT (2X,16HTOTAL INVESTMENT)
      PRINT 112,(CI(K),K=MM,NN)
  112 FORMAT (2X,11HCOST (000) ,10F10.0)
C
C     PRINT TOTAL OPERATING COST
C
      PRINT 114
  114 FORMAT (1H )
      PRINT 113
  113 FORMAT (2X,15HTOTAL OPERATING)
      PRINT 112,(CO(K),K=MM,NN)
      IF (NN.EQ.N) GO TO 200
      NN=N
      MM=12
      PRINT 90
      GO TO 1000
  200 IF (IDUMP .NE. 1) CALL EXIT
      WRITE (6, 210)
  210 FORMAT (1H1// 58X, 11HCOMMON DUMP /// 8X, 1H1, 11X, 1H2, 11X, 1H3,
     1 11X, 1H4, 11X, 1H5, 11X, 1H6, 11X, 1H7, 11X, 1H8, 11X, 1H9, 10X,
     1 2H10, 6X, 9HADDRESSES // )
      DO 230 I=1, 3041, 10
      J = I + 9
      WRITE (6, 220) (A1(K), K = I, J), I, J
  220 FORMAT (1X, 10(F11.3, 1X), 2X, I4, 1H-, I4)
      FFF1 = I/50
      FFF2 = FLOAT(I)/50.
      IF (FFF1 .EQ. FFF2) WRITE (6, 210)
  230 CONTINUE
      CALL EXIT

      END
```

Appendix A-III

LISTING OF JOSS SURVIVAL SCHOOL PROGRAM

```
Delete all.
Use file 640 (m7490).
Roger.
Recall item 3 (surv).
Done.

Type all.

1.00 Demand Z as "Annual graduates required".
1.01 Demand B as "Course length, weeks".
1.02 Demand C as 2ratio of field instructors to students".
1.03 Demand D as "Ratio of resistance instructors to students".
1.04 Demand E as "Fixed number of instructors and supervisors".
1.05 Demand F as "Ratio of variable admin. pers. to op.+admin. pers".
1.06 Demand G as "Fixed number of admin. personnel".
1.07 Demand H as "Ratio of variable BOS PERS TO OP]*ADMIN] PERS".
1.08 Demand I as "Fraction of fixed inst. allocated to pilot tng".
1.09 Demand J as "Fraction of fixed admin pers alloc to pilot tng".
1.10 Demand K as "Fraction of officers in BOS".
1.11 Demand L as "Fraction of airmen in BOS".
1.12 Demand M as "Fraction of officers in admin.".
1.13 Demand N as "Fraction of airmen in admin.".
1.14 Demand O as "Fraction of officers in instructors + supervisors".
1.15 Demand P as 2do you want cost estimate? (yes=1, no=0)".
1.16 To part 2 if P=0.
1.17 To part 23 if P=1.

2.00 Set a=Z·B/52.143.
2.01 Set b=a·(C+D).
2.02 Let d=F·(a+b).
2.03 Let g=H·(a+b+d).
2.04 Let c=I·E.
2.05 Let e=c·F.
2.06 Let i=H·(c+e).
2.07 Let f=J·G.
2.08 Let j=H·f.
2.09 Let h=K·(g+i+j).
2.10 Let k=L·(g+i+j).
2.11 Let l=g+i+j-h-k.
2.12 Let m=M·(d+e+f).
2.13 Let n=N·(d+e+f).
2.14 Let o=d+e+f-m-n.
2.15 Let p=O·(b+c).
2.16 Let q=b+c-p.
2.17 Let r=a+p+m+h.
2.18 Let s=k+n+q.
2.19 Let t=l+o.
2.20 Let u=r+s.
2.21 Let v=u+t.
2.22 Let w=h+k+l.
2.23 Let x=m+n+o.
2.24 Let y=p+q.
2.25 Let z=r+s+t.
2.26 Type " Set tab at 40, then type Do part 3.".
```

```
3.0 Line.
3.1 Type form 1.
3.2 Type h,k,l,w in form 2.
3.3 Type m,n,o,x in form 3.
3.4 Type p,q,y in form 4.
3.5 Type a,a in form 5.
3.51 Type r,s,t,z in form 6.
3.6 Line.
3.7 Type u in form 7.
3.8 Type v in form 8.
3.9 Line.
3.91 To part 1 if P=0.
3.92 To part 6 if P=1.

5.00 Demand A(27) as "Sq. t. classroom req'd/student".
5.01 Demand A(28) as "Sq. ft. classroom on hand".
5.011 Demand A(29) as "$/sq. ft. classroom".
5.02 Demand A(31) as "$ rn. eq. and spares on hand".
5.03 Demand A(32) as "Trn. eq. and spares , $/student".
5.04 Demand A(33) as "Initial trn. cost, officers".
5.05 Demand A(34) as "Initial travel cost, officers".
5.06 Demand A(35) as "Initial trn. cost, airmen".
5.07 Demand A(36) as "Initial travel cost, airmen".
5.08 Demand A(37) as "$ supplies/military man".
5.09 Demand A(38) as "$ base spt. eq. and spares/military man".
5.10 Demand A(39) as "$ base spt. eq. and spares on hand".
5.11 Demand A(40) as "Sq. ft. housing req'd/student".
5.12 Demand A(41) as "Sq. ft. housing on hand".
5.13 Demand A(42) as "$/sq. ft. housing".
5.14 Demand A(43) as "Facility R+M, $/man/year".
5.15 Demand A(44) as "Base pt. eq. R+M,$/man/year".
5.16 Demand A(45) as "Annual services, $/man/year".
5.17 Demand A(46) as "Supplies, $/man/year".
5.18 Demand A(47) as "Student pay + allowances".
5.19 Demand A(48) as "Officer pay + allowances".
5.20 Demand A(49) as "Airman pay + allowances".
5.21 Demand A(50) as "Civilian pay + allowances".
5.22 Demand A(51) as "PCS cost, officers".
5.23 Demand A(52) as "Officer turnover rate".
5.24 Demand A(53) as "PCS cost, airmen".
5.25 Demand A(54) as "Airman  turnover rate".
5.26 Demand A(55) as "Student TDY cost".
5.27 Demand A(56) as "$ initial supplies on hand".
5.28 Demand A(57) as "No. f perm. party officers at school last yr.".
5.29 Demand A(58) as "No. of erm. party airmen at school last year.".
5.30 To part 2.

6.00 Set P(49)=a·A(27).
6.01 To part 7 if P(49)>A(28).
6.02 Set P(51)=0.
6.03 To part 8.

7.00 Set P(50)=P(49)-A(28).
```

```
7.01 Set P(51)=P(50)·A(29).
7.02 To part 8.

8.00 Set P(52)=a·A(32).
8.01 To part 9 if P(52)≤A(31).
8.02 Set P(53)=P(52)-A(31).
8.03 To part 10.

9.00 Set P(53)=0.
9.01 To part 10.

10.00 Set P(55)=p+m+h-A(57).
10.01 Set P(56)=0.
10.02 Set P(57)=0.
10.03 To part 11.

11.0 Set P(56)=P(55)·A(33).
11.1 Set P(57)=P(55)·A(34).
11.2 To part 12.

12.00 Set P(58)=s-A(58).
12.1 To part 13 if P(58)>0.
12.2 Set P(59)=0.
12.3 Set P(60)=0.
12.4 To part 14.

13.0 Set P(59)=P(58)·A(35).
13.1 Set P(60)=P(58)·A(36).
13.2 To part 14.

14.00 Set P(61)=A(37)·u.
14.1 To part 15 if P(61)>A(56).
14.2 Set P(82)=0.
14.3 To part 16.

15.00 Set P(82)=P(61)-P(58).
15.1 Set A(56)=P(61).
15.2 To part 16.

16.0 Set P(63)=u·A(38).
16.1 To part 17 if P(63)>A(39).
16.2 Set P(64)=0.
16.3 To part 18.

17.0 Set P(64)=P(63)-A(39).
17.1 To part 18.

18.0 Set P(65)=a·A(40).
18.1 To part 19 if P(65)>A(41).
18.2 Set P(66)=0.
18.3 To part 20.

19.0 Set P(66)=A(42)·(P(65)-A(41)).
19.1 Set A(41)=P(65).
```

```
19.2 To part 20.

20.00 Set P(67)=u·A(43).
20.01 Set P(68)=u·A(44).
20.02 Set P(69)=u·A(45).
20.03 Set P(70)=u·A(46).
20.04 Set P(71)=a·A(47).
20.05 Set P(72)=A(48)·(r-a).
20.06 Set P(73)=s·A(49).
20.07 Set P(74)=t·A(50).
20.08 Set P(75)=A(51)·A(52)·(r-a).
20.09 Set P(76)=s·A(53)·A(54).
20.10 Set P(77)=A(55)·Z.
20.11 Set P(78)=A(52)·A(33)·(r-a).
20.12 Set P(79)=s·A(54)·A(35).
20.13 Set P(80)=P(51)+P(56)+P(57)+P(59)+P(60)+P(82)+P(64)+P(66)+P(53).
20.14 Set P(81)=P(67)+P(68)+P(69)+P(70)+P(71)+P(72)+P(73)+P(74).
20.15 Set P(83)=P(81)+P(75)+P(76)+P(77)+P(78)+P(79).
20.151 Line.
20.16 To part 21.

21.0 Type "INVESTMENT COSTS".
21.01 Type P(51) in form 9.
21.02 Type P(53) in form 10.
21.03 Type P(56) in form 11.
21.04 Type P(57) in form 12.
21.05 Type P(59) in form 13.
21.06 Type P(60) in form 14.
21.07 Type P(82) in form 15.
21.08 Type P(64) in form 16.
21.09 Type P(66) in form 17.
21.10 Type P(80) in form 31.
21.11 Line.
21.12 To part 22.

22.00 Type "ANNUAL OPERATING COSTS".
22.01 Type P(67) in form 18.
22.02 Type P(68) in form 19.
22.03 Type P(69) in form 20.
22.04 Type P(70) in form 21.
22.05 Type P(71) in form 22.
22.06 Type P(72) in form 23.
22.07 Type P(73) in form 24.
22.08 Type P(74) in form 25.
22.09 Type P(75) in form 26.
22.10 Type P(76) in form 27.
22.11 Type P(77) in form 28.
22.12 Type P(78) in form 29.
22.13 Type P(79) in form 30.
22.14 Type P(83) in form 32.
22.15 Line.
22.16 Demand Q as "Are new manning inputs desired.(Yes=1, No=0).".
22.17 To part 1 if Q=1.
22.18 To part 23 if Q=0.
```

```
23.0 Demand R as "Are new cost inputs desired. (Yes=1, No=0).".
23.1 To part 5 if R=1.
23.2 To part 24 if R=0.

24.0 To part 2 if Q=1.
24.1 To part 25 if Q=0.

25.0 Type "End of program".
```

Form 1:

	OFFICERS	AIRMEN	CIVILIANS	TOTAL
Form 2: BOS	______	______	______	______
Form 3: Admin.	______	______	______	______
Form 4: Instructors	______	______		______
Form 5: Students	______			______
Form 6: Total	______	______	______	______

Form 7:
Total military ________

Form 8:
Total personnel ________

Form 9:
Classrooms ________

Form 10:
Training equipment and spares ________

Form 11:
Initial training, officers ________

Form 12:
Initial travel, officers ________

Form 13:
Initial training, airmen ________

Form 14:
Initial travel, airmen ________

Form 15:
Initial supplies ________

Form 16:
Base support equipment and spares ______________

Form 17:
Housing ______________

Form 18:
Facilities R+M ______________

Form 19:
Base support equipment R+M ______________

Form 20:
Annual services ______________

Form 21:
Annual supplies ______________

Form 22:
Student pay and allowances ______________

Form 23:
Other officer pay and allow. ______________

Form 24:
Airmen pay and allowances ______________

Form 25:
Civilian pay and allowances ______________

Form 26:
Annual travel, officers ______________

Form 27:
Annual travel, airmen ______________

Form 28:
TDY, Students ______________

Form 29:
Replacement training, officers ______________

Form 30:
Replacement training, airmen ______________

Form 31:
Total investment costs ______________

Form 32:
Total operating costs ______________

Type size.
size = 1387

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